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of the

American Ceramic Society

Ceramic Abstracts and the Bulletin

A Monthly Journal devoted to the Arts and Sciences Related to the Silicate Industries

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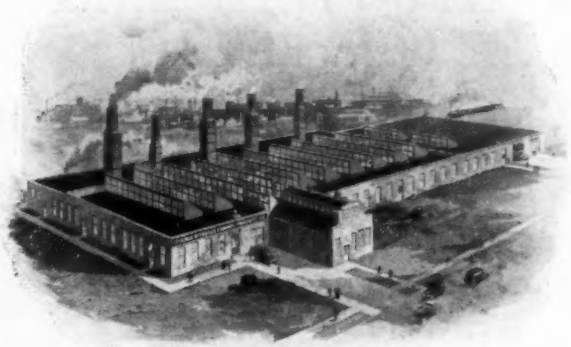

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ORIGINAL PAPERS

IMPACT TESTS ON TABLEWARE[1]

BY H. H. SORTWELL

ABSTRACT

Impact tests were conducted on sets of plates of six thicknesses covering the range of from 1/8 to 3/8 inch, contributed by five potteries, three making semi-porcelain and two vitrified china. The plates were struck in the center and both "starring" and complete failure were observed.

It was found that in all types tested the impact to cause "starring" increased with the thickness in an approximately parabolic relation.

In plain semi-porcelain household plates and rolled edge vitrified hotel china difference in thickness within the range in which such ware is ordinarily made, had no appreciable effect on the ability of the ware to withstand complete failure by impact.

In the double-thick semi-porcelain hotel plates tested the strength increased with increase in thickness and the ultimate impact strength was much higher than for the other types, probably due to the reinforcing effect of the heavy rim.

Introduction

Results of impact tests made on seven-inch plates at the Bureau of Standards showed that somewhat wide variations in thickness exist in different brands of ware as marketed. Since the relations between thickness and resistance to impact were not known, it became apparent that additional tests would have to be made to provide data on these relations

[1] Published by permission of the Director of the Bureau of Standards of the U. S. Department of Commerce.

before satisfactory comparisons of results on specimens of different thicknesses could be made.

This problem was discussed at a joint meeting of the Research Committee of the United States Potters' Association and the Bureau of Standards, and several members of the committee offered to have plates made covering a wide range in thickness for this purpose.

Testing Procedure

Samples were submitted by five potteries, three making semi-porcelain and two vitreous hotel china. The plates were jiggered in six thicknesses to cover the range from $^1/_8$ to $^3/_8$ inch, and were divided into three sets which were fired in the first, second and third rings in the bisque kiln. The plates were then glazed as usual.

The method of testing consisted in striking the plate in the center with the bottom resting against three one-eighth inch steel balls equidistantly spaced around a ring three and one-quarter inches in diameter, which has been previously described in detail.[1] The first blow had an energy of 0.025 ft.-lbs. and each successive blow was increased 0.0125 ft.-lbs. The first occurrence of "starring," any failure of glaze or body, and the final failure when the plate was completely fractured or cracked enough to be pulled apart by the hands, were observed.

Results

The results of the tests are given in Table I. Since the results on plates

TABLE I

RESULTS OF IMPACT TESTS

Ware	Average thickness in inches	Average blow causing "starring," ft.-lbs.	Average blow causing failure, ft.-lbs.
No. 1 Semi-porcelain	0.130	0.0498	0.1907
	.176	.0620	.1815
	.219	.0977	.1814
	.275	.1554	.2004
	.331	.2408	.2608
	.382	.3588	.3668
No. 2 Semi-porcelain	0.140	0.0358	0.1802
	.173	.0495	.1704
	.225	.0826	.1782
	.268	.1300	.1982
	.307	.1812	.2140
	.352	.2746	.2879
	0.178	0.0544	0.2756
	.203	.0659	.3366

[1] H. H. Sortwell, *Jour. Amer. Ceram. Soc.*, **5** [6], 276 (1922).

No. 3	0.241	0.0899	0.3787
Semi-porcelain	.260	.1174	.3771
	.308	.1561	.3931
	.347	.2265	.4423
	0.120	0.0383	0.1979
	.155	.0534	.2387
No. 4	.172	.0708	.2316
Vitreous china	.210	.1103	.1995
	.245	.1708	.2108
	.281	.2092	.2356
	0.113	0.0375	0.1541
	.143	.0550	.1562
No. 5	.169	.0875	.2250
Vitreous china	.210	.1012	.2250
	.247	.1750	.2185
	.274	.2410	.2875

of the same thickness fired in different rings in the bisque kiln varied but little and not always consistently with the variation in heat treatment, space is taken in this publication for only the average for the plates of each brand and thickness. Comparison of the results on plates of the same

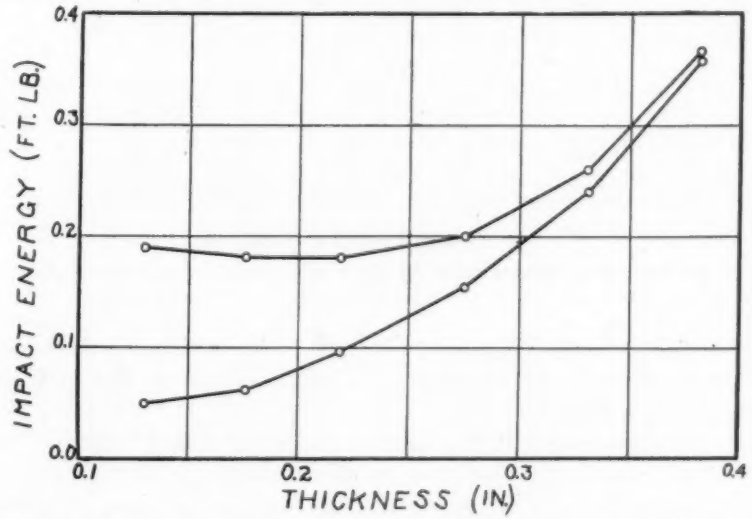

FIG. 1.—Results of impact tests on plain semi-porcelain household plates (Ware No. 1).

thickness fired in different rings in the bisque kiln showed that ware uniform in respect to this test can be burned in the ordinary potter's kiln.

Fig. 1 shows graphically the results on plain semi-porcelain household plates of one make. The results are the average for thirty plates of each

thickness. The upper curve indicates the blow at which the plate broke, while the lower curve shows the first occurrence of "starring."

Beginning at a thickness of 0.130 inch, with increasing thickness the ultimate strength first showed a slight drop, followed by a slight rise to about 0.275 inch, after which further increases in thickness increased the strength more abruptly. Between these thicknesses the thickness appeared to have only a slight effect on the ability of the ware to withstand blows as indicated by this test, and in comparing plates of this type differences in thickness within this range might be ignored. Practically all American semi-porcelain household plates fall between $^1/_8$ and $^3/_{16}$ inch in thickness of the bottom and the curve shows that little is to be

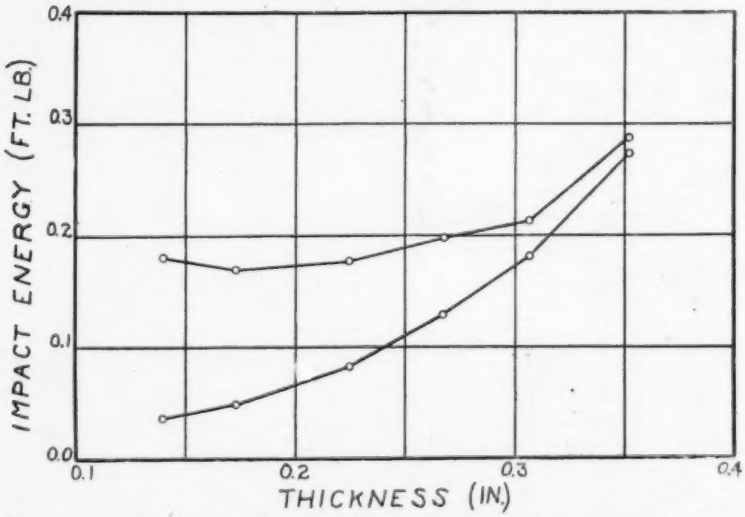

FIG. 2.—Results of impact tests on plain semi-porcelain household plates (Ware No. 2).

gained in the ultimate resistance to impact by increasing the thickness of the bottom of these plates above $^1/_8$ inch. However, the "starring" is also to be considered.

In all thicknesses except the greatest the effect called "starring" consisted of the cracking of the glaze on the bottom side of the plate. In the thicker plates the "star" penetrated the body of the ware. The lower curve in Fig. 1 indicates the impact at which this occurred in this ware. The blow required to produce "starring" increased with increase in thickness of the plate. The relation of these factors for this ware followed closely the parabola

$$y = 3x^{2.236}$$

in which y equals the impact energy in foot-pounds causing "starring" and x equals the thickness of the plate.

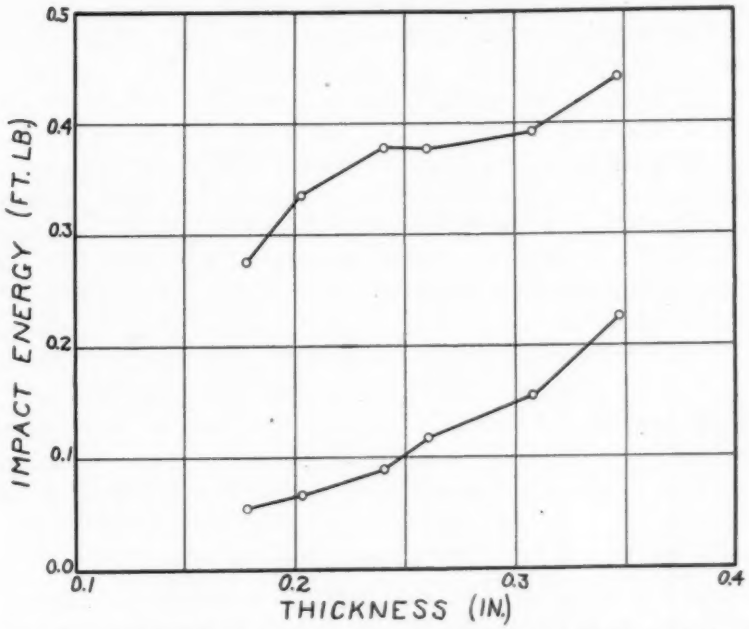

FIG. 3.—Results of impact tests on double-thick semi-porcelain hotel plates (Ware No. 3).

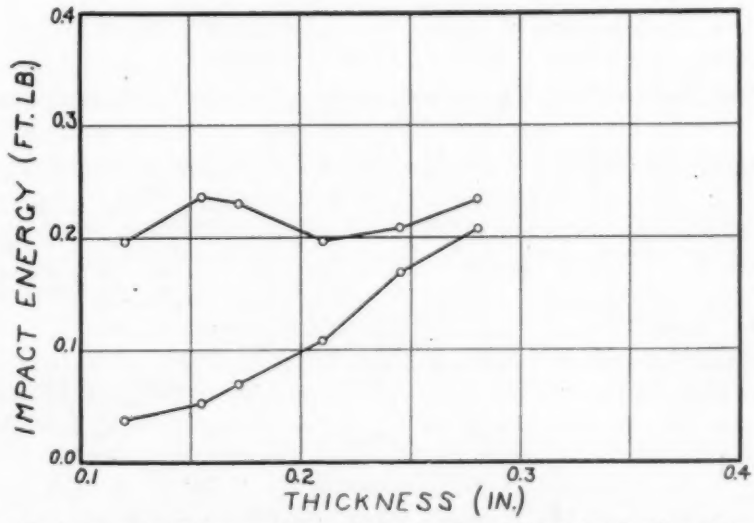

FIG. 4.—Results of impact tests on rolled edge vitrified hotel china plates (Ware No. 4).

Fig. 2 shows the average results of sixty plates of each thickness of a different brand of plain semi-porcelain household plates. Both the curve indicating the ultimate impact strength and that showing "starring" followed the same trend as those in Fig. 1 and the foregoing discussion of these results applies equally well to this brand with the exception that the parabolic equation would be somewhat different.

Considered collectively, the results on these two brands appear to check each other in regard to the impact-thickness relations.

Fig. 3 shows the average results on double-thick, plain edge, semi-porcelain hotel plates with very thick rims. About twenty plates of each thickness were tested.

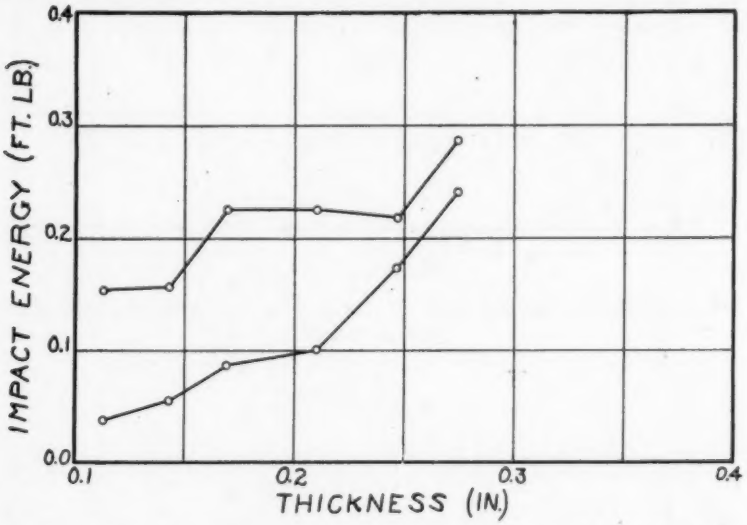

FIG. 5.—Results of impact tests on rolled edge vitrified hotel china plates (Ware No. 5).

While the curve showing the relation of thickness to the impact energy causing "starring" is very similar to those for brands 1 and 2, the curve denoting failure differs considerably. In general the resistance to impact of this type of plate increased with increase in thickness, although the effect was only slight between thicknesses of 0.24 and 0.31 inch.

The impact causing failure of these plates is much higher than any of the other types tested, which is probably due to the stiffening of the bottom of the plate by the very thick rim. This difference in design also probably accounts for the difference in the relation of the thickness to the impact causing failure.

Fig. 4 shows the results on one brand of vitreous hotel china of the ordinary rolled edge design. The lower curve indicating "starring" is a parabolic curve similar to those for the other brands of ware. The results

for impact failure of these plates were not consistent and the thickness of the ware appeared to have no regular relation to the blow causing failure. The thickness could be ignored in comparing results of impact tests on these plates of different thicknesses within the range in thickness in which they are ordinarily made.

Within the limits of commercial thicknesses these plates failed at a somewhat greater blow than brands 1 and 2, plain semi-porcelain household plates, but at considerably lower blows than brand 3, double-thick, plain edge, semi-porcelain hotel ware.

Fig. 5 shows the results on a second brand of vitrified hotel china rolled edge plates. In this case, as in the others, the impact causing "starring" increased with the thickness in an approximately parabolic curve. The relation of the impact causing failure to the thickness was more regular than in brand 4, and while increase in thickness increased the ability to withstand impact, it will be noted that within the range in thickness in which these plates are made commercially, the thickness had no effect on the blow causing fracture.

Summary

The impact force causing "starring" of seven-inch plates of all types tested increased with increase in thickness in an approximately parabolic relation.

Increase in the thickness of plain semi-porcelain household plates within the range in thickness in which such plates are made commercially had no appreciable effect on the impact causing complete failure of the plate. At greater thicknesses increase in the thickness did increase the ability to withstand impact at the center.

In double-thick semi-porcelain hotel plates the ultimate impact strength increased irregularly with increase in thickness and the blow causing failure was much higher than for the other types of plates tested, due to the bracing effect of the very thick rim.

The impact causing complete failure of vitrified hotel china plates did not appear to vary regularly with the thickness.

These results indicate that in comparing results of impact tests of this kind on commercial plain and rolled edge plates, small differences in thickness may be ignored.

In designing plates little is to be gained in resistance to impact as indicated by the Bureau of Standards test, by increasing the thickness within the commercial limits, but the resistance to "starring" is increased by increasing thickness.

The author wishes to thank Messrs. A. V. Bleininger, F. K. Pence, C. E. Jackson, James M. Smith and Thomas B. Anderson and the companies with which they are associated for contributing the sets of plates tested in this work.

BUREAU OF STANDARDS
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SOME NOTES ON HISTORICAL AND MODERN DECORATIVE PROCESSES[1]

By Frederick H. Rhead

ABSTRACT

A review of the best known ceramic decorative processes. The various processes are described and a classification is suggested for the different types. The decorative types dealt with are: 1. Incised processes. 2. Modeling. 3. Slip decorations. 4. Underglaze. 5. Polychrome Glaze Decorations. 6. Monochromes. 7. Lustre. 8. Overglaze Processes. 9. Ceramic Sculpture. 10. Architectural Terra Cotta and Faience. The general conditions involved in the production of ceramic wares in the craftsman's age and the present industrial age are described.

The possible field for research in ceramic decorative process work is so large that it would be impossible to cover the ground in a lifetime, even if one concentrated on a single process. In fact, the practical potter and the decorative man are seldom familiar with more than one or two methods of manufacture, and at the most, two or three decorative processes.

Manufacturers of clay products usually confine their activities to the production of individual types which may be classified into such broad groups as:

(1) **Refractories.**—Embracing the production of firebrick, muffles, crucibles, saggers, kiln fixtures, etc.

(2) **Industrial Porcelain.**—Covering such types as electrical and chemical porcelain, fixtures and utensils for various industrial purposes.

(3) **Stoneware.**—Including chemical and utilitarian stoneware; sewer pipe, etc.

(4) **Sanitary Ware.**—Bathroom, kitchen and lavatory equipment.

(5) **Earthenware and China.**—Table and general utilitarian wares.

(6) **Architectural Wares.**—Ranging from the ordinary building brick and the commercial floor and wall tile to the more or less elaborate terra cotta and architectural faience.

(7) **Art Wares.**—Including the various types of ornamental pottery used largely for decorative purposes.

The range appears yet more comprehensive when it is realized that each type requires entirely different manufacturing conditions, and its own particular class of organization, factory equipment, technical and practical attitude, type of labor, market and consumer.

A wide variety of clays are used, possessing many different physical properties, and varying in action according to their place in a particular composite body. The clays may be ground and washed, or they may be of course texture and altogether unrefined. They may be of different degrees of plasticity, and ranging from the exceedingly stiff pugged mixtures used in some machine pressed wares to the slushy consistencies used in some of the art pottery wares. They may be used in the form of moist

[1] Paper read during the Annual Convention, American Ceramic Society, St. Louis, 1922.

dust for floor and wall tile presses, and for electrical fixtures, or they may be used in the liquid state in consistencies varying from eighteen to thirty ounces to the pint.

Kiln temperatures in general practice vary from the soft faience limits of cone 05 or thereabouts to the porcelain and refractory temperatures of cone 16 and higher. Cone 9 or 10 is no longer the commercial limit. In fact cone 16 is the minimum temperature for certain industrial wares.

Considering the possibilities in ceramic decorative process work, the potter is always bound by temperature limits. Maximum temperatures of cones 1, 5, 10, 15, and 20, will each result in the production of technical types varying from the other according to the position the others occupy in the range. As the temperature limit is increased, the use of certain fluxes is lessened or discontinued, and others are substituted. The change is so complete that what may serve as a clay body at a low temperature may easily be adapted as a glaze at a higher heat; while a number of the higher temperature glazes now in use would in effect be opaque or translucent bodies in the lower temperature ranges. These conditions suggest the enormous number of variations and the differences in manufacturing conditions when the various ceramic processes are considered.

The art of the potter is simple as well as complex. It is full of contradictions. There are very few assertions or conclusions relating to ceramic work which cannot be debated or considered to have many interpretations. In its simplest aspect, and speaking quite broadly, one might say that the art of the potter consists in the molding of the plastic element to a required form, and the subjection of this form to sufficient heat to harden or crystallize the clay mass. This is much the definition that would be considered satisfactory to a superficial interest in the subject. A general knowledge of the commercial processes, and the ability to define these processes in concrete examples is evidence that the dealer and salesman are well read in their respective fields. To the manufacturer who is interested in the production and disposition of his goods, this interest concentrates on conditions surrounding one type. He knows the performance of certain kinds of equipment, of certain classes of labor, of market conditions pertaining to his own particular productions. The factory manager is in much the same position, and so are the specialists engaged in one class of work. For the craftsman, it is enough if he possesses the ability to execute a single type, working much in the manner of the medieval craftsmen, but taking advantage of such modern developments as the portable kiln which works much with the precision of the kitchen stove. There are many specialists who are well read on process work. But knowledge or intimacy of the various branches, or of any particular branch must be derived through practical experience with production. Any theoretical knowledge

must be supported or backed by activity which will successfully produce concrete results. A successful laboratory experiment will corroborate a scientific theory, but there still remains the very practical problem of large scale production within a definite cost limit, whether in the form of quantity units, or in regard to the individual size of the job, as in the case of a big architectural work.

An expert may know definitely that any particular process is entirely practical, he may possess knowledge to formulate a program, design equipment, and define conditions for the production, but unless there is also the ability to carry out that program, the ability that will anticipate unfavorable conditions, rather than deal with them as they arise, there is a serious lack of practical experience which should be present, whether it be possessed by the technical man or by the practical potter.

This lack of practical experience is one of the chief problems confronting the ceramic manufacturer today, and it is one of the reasons why he should exert every effort to bring about a condition where we will have industrial schools for training practical potters.

While this somewhat lengthy transgression might be thought to be foreign to the subject of this paper, its purpose is to bring to the attention of those who are interested, a realization of the conditions which must have existed in connection with the production of the types to be discussed; conditions which unfortunately do not exist in this country except in a few isolated cases. In reviewing the practical methods employed in the production of the various types, developments which have been possible only as the result of grinding and intensive practical research in each case, the modern practical ceramist will not only acquire a knowledge of his debt to the pioneers in the various fields, but he will (or should) learn something of the conditions necessary for the continuance of the various developments.

In attempting to review some of the processes practiced by potters of various countries and periods, I will not touch upon the preparation and manipulation of the materials except where there is a direct relation to the decorative process in question, but will describe the best known historical and modern types, using illustrations when these will clarify the point under discussion.

I divide my references into ten broad groups, as follows: (1) Incised, etched and carved processes; (2) modeled relief processes; (3) slip processes; (4) underglaze processes; (5) polychrome glaze processes; (6) monochromes; (7) luster processes; (8) overglaze decorations; (9) ceramic sculpture; (10) architectural pottery.

1. Incised, Etched and Carved Processes

It is obvious that all primitive processes would be simple in method. About all the primitive could do would be to scratch on the surface of the

form. That natural decorative instinct of the savage, an instinct that has almost been cultivated out of existence in this so-called civilized age, was always active and ever present.

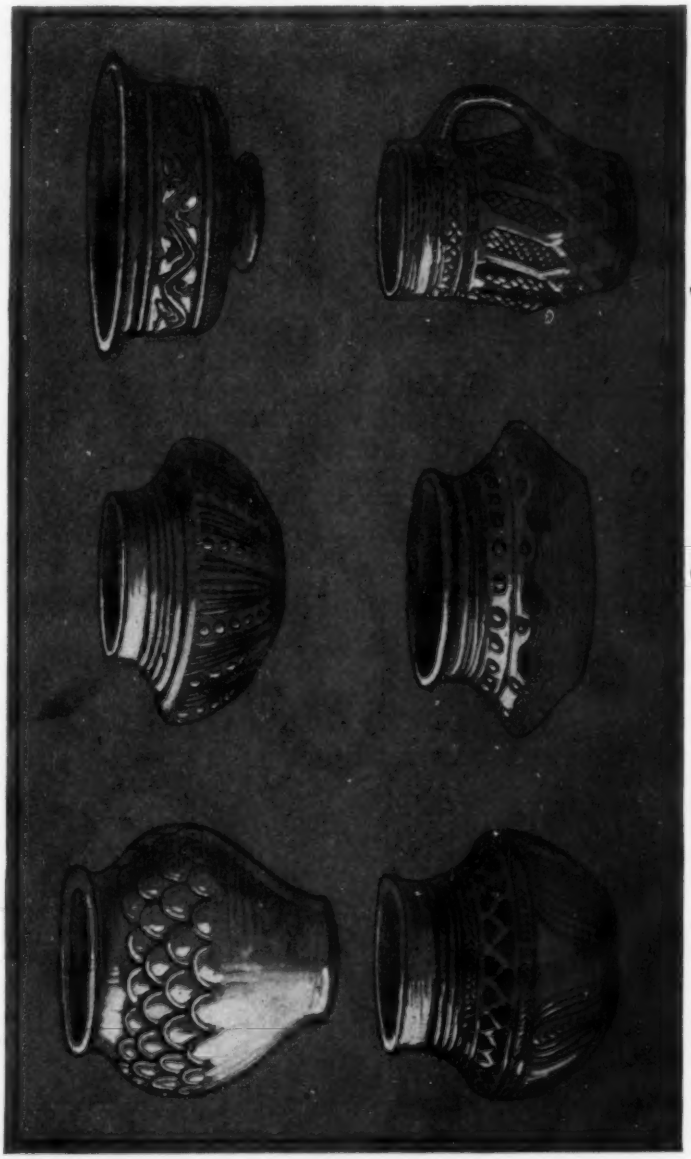

FIG. 1.—Early British pottery.

Upon the completion of the shape, the potter might be dissatisfied with the crudeness of the form, and scratch over the surface to divert the attention from lack of finish, or being satisfied with the result, would be

moved to carry the work still further, and so scratch whatever symbols or signs came to mind.

Whatever the idea may be, the means are primitive enough. A blunt pointed stick is used and the decoration incised upon the shape.

Plastic clay lends itself excellently to the incised processes. Quite elaborate designs may be worked out if the potter possesses a sense of design and is skilful in using the tool.

As clay varies in its working and plastic qualities, it follows that the texture of the clay would to some extent control the method and execution. Some clays can be incised while the clay is in a soft plastic condition, and with an ordinary blunt point, while other clays, porcelains for instance, are incised or carved while in a harder or less plastic state. Under such conditions tools made from Swiss files or old dental tools are used. For plastic surfaces, tools made from ordinary darning needles are most satisfactory. The point of the needle is inserted in a convenient handle, and the eye is sharpened around the edge. A well-made tool of this character will make a clear line without a ragged edge. The excised clay comes through the eye of the needle leaving a cleanly cut and delicate line.

There are three kinds of incised line: (1) The line made by pressing the tool to the soft plastic surface; (2) by dragging or pulling the tool over the outline, as in the case of the needle tool; (3) and the carved line executed when the clay object is almost or quite dry.

Types of Incised, Etched and Carved Processes.

(*a*) Archaic pottery.
(*b*) Early Celtic burial urns.
(*c*) Indian pottery.
(*d*) Carved Chinese pottery and porcelain.
(*e*) European craft pottery.
(*f*) Sgraffito. (Combination of the slip and incised processes.)
(*g*) Incised glaze process. (A hard enamel or fusible slip is applied to the clay form, and the design is incised and cut through the outer coat to the clay body.)

2. Modeled Relief Processes

Every potter knows, or should know, the important place the modeler should occupy in most potteries. He is responsible for the execution of all ornamental relief, and the form to which this is applied.

His treatment of a particular subject will determine the character of mold to be used. It is the tendency in commercial practice to simplify mold construction. Articles such as teacups, pitchers, coverdishes and teapots, which used to be cast from molds having separate parts for the handles and spouts are now cast with these already on the shape. In such branches of ceramic work as architectural faience and terra cotta, the modeler is really a sculptor, while in the utilitarian ware branches he is a

highly skilled mechanical craftsman. In commercial practice, an inefficient modeler may cost a concern large sums annually. Lack of mechanical accuracy, disregard of the current contraction scale and warpage

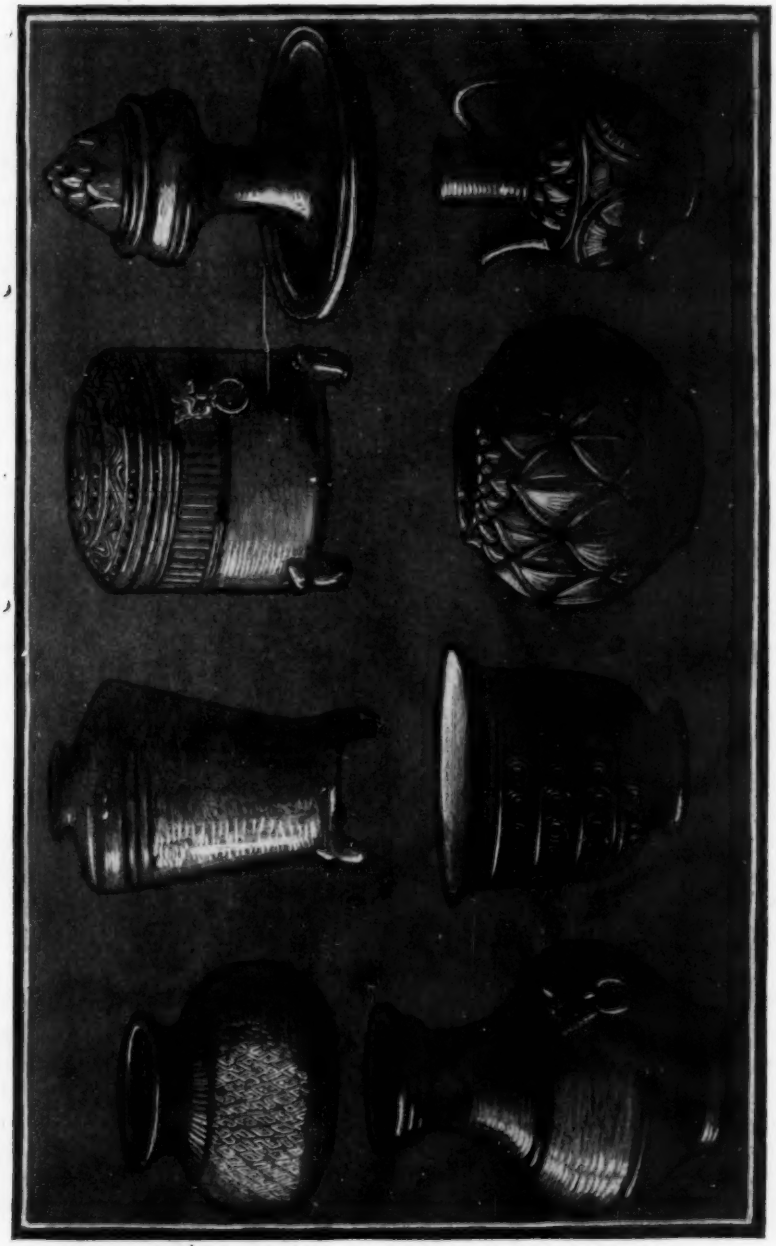

FIG. 2.—Ancient Chinese pottery.

curves, are contributory causes to unsatisfactory product and loss which could be directly traced to the original model providing there is present the practical knowledge that can trace and check such faults.

Original Development of Modeled Decorations.—As the primitive became more familiar with his material, it would occur to him that he might add clay to the surface instead of incising or carving it from the shape. The first developments were most probably combinations of the two methods such as adding dabs or buttons of clay to emphasize the incised places. As the early potter realized the possibilities of work in relief more elaborate specimens were executed. The Grecian and Roman terra cottas, and some of the Chinese pieces of the Han and Sung periods are typical examples.

Plaster molds were not in general use until about 1750, although they are said to have been used in Italy in the sixteenth century. Before this, molds were made of porous terra cotta and various metals. The primitives used fruit forms and baskets for molds. Because of the harder substances formerly used in making molds, many of the early pieces are remarkably clear and sharp in relief.

Eler's Ware (English).—Reliefs were obtained by pressing seals or intaglio molds to the surface of the ware. Thin slabs of soft plastic clay were placed over the desired spot, the stamp pressed against this, and the rough edges cleaned off. At this period such stamps were extensively used, especially in connection with red wares and stoneware.

Wedgwood Ware.—Wedgwood reliefs were pressed from porcelain molds and then applied to the surface of the ware. The shape would be made on the wheel and afterwards turned on the lathe. Wedgwood developed this combination of the two processes to a very high degree. A shape would be put on the lathe half a dozen times to attain a finish which could not be completed in fewer operations. The shape would be roughly turned, then inserted in a hollow form for support while the foot was being turned. The piece would then be dipped in a dark blue or some other colored slip, dried to a firm plastic condition and again put on the lathe to be polished and to have the lines, borders, and other details executed. Wedgwood used wheel dies called runners which were pressed against the revolving shape, and any number of mechanical devices for obtaining various results.

When the shape was completed the clay reliefs were pressed from the porcelain dies and applied to the form, using water as the adhering liquid. Every detail in this process requires a high degree of mechanical skill, especially so, when it is realized that in the final operation when the figures are applied on the ware, the piece must still be in the plastic state.

Palissy (1510–1589).—Palissy often produced reliefs from molds which were cast from metal or natural objects, a method resulting in clear and

sharp reliefs often mechanical in effect. Palissy's reliefs were nearly always in the mold and not applied to the ware itself as was done by Wedgwood and the Eler's.

German and French Stoneware (1400–1800).—Examples of careful potting and mechanical finish. Much of this ware was made in a stoneware body well washed and often finely screened, generally finished in salt glaze. The reliefs were both incorporated in the shape mold and applied by means of stamp dies. Factories producing such wares were located at Grenzhausen, 1780, Siegburg, about 1570, Limburg, 1580, Cologne, 1600, Bayreuth, 1600 and in other places in Germany, and at Saint Porchaire (I allude to the Henri Deux ware made between 1524 and 1537, and called by the French: Faience d'Oiron), Beauvais, Apt, Avignon, 1650 to 1780 and Paris, 1560.

3. Slip Processes

As the craftsmen interested in sculpture would naturally lean toward relief decorations, so the potter interested in painting would seek out possibilities in flat surface decorations. The primitive had no further resources so far as his palette was concerned than the various natural colored clays at hand. As his wares were burned at a comparatively low temperature he had few problems of contraction to contend with. He selected his colors, generally a palette limited to red, black, ocher and white, and applied these directly to the surface.

With the developments in process came more refined methods. Other colors were added to the palette by staining the white and lighter colored clays with calcinations of mineral oxides, and naturally the technical field became more involved. Decorations subjected to a high degree of heat became more subject to the law of contraction. If the applied slip did not shrink evenly with the ware, it scaled off either before the ware was dry, or after it was fired. Color combinations had to be carefully thought out with the chemical action in mind. Chrome green slips could not be mixed with yellows or browns containing iron if the greens were to be retained. In what is known as the Rookwood type of slip painting, where an iron yellow glaze is used the greens are obtained from cobalt combinations and are consequently quite blue in hue until the yellow glaze is applied and fired.

Some of the modern slip processes are very elaborate, and require a high degree of skill in execution. Faience, earthenware, stoneware and porcelain bodies are equally appropriate for these processes, and the potters of the various countries have produced fine examples of slip decoration in all these bodies.

Types of Slip Processes.

(*a*) Primitive slip processes using natural clays.
(*b*) Slip processes of the Toft school.
(*c*) French barbotine processes.
(*d*) European craft pottery, Black Forest school.
(*e*) Rookwood school.
(*f*) Copenhagen and Sèvres school porcelain.
(*g*) Pâte-sur-pâte, Sèvres and Mintons.

(*a*) **Primitive Slip Processes.**—Examples of slip decorated pottery have been produced in all countries where pottery has been made. But the slip decorations of the British under Roman influence (A. D. 117–138), the Anglo-Saxons about 580, and from the date of the Norman conquest to the sixteenth and seventeenth centuries (Toft and Eler s school), are probably the most typical.

(*b*) **The Toft School.**—The Toft school is one of the most interesting of the early influences. Thomas and Ralph Toft (1660–1676), lived in a period when the local craftsmen were beginning to realize the possibilities in ceramic decorative work. With few mechanical devices, a practical knowledge limited to throwing and turning, and the other elementary processes of the time, and without any foreign decorative influence, the wares of the Tofts and their followers are distinctly English in type. The quaint conventionalizations of historical and local personages are very cleverly spaced, and the inscriptions and ornamental details naively reflect not only the personal interest of the craftsman in his work, but the spirit and atmosphere of the period.

The ware, as suggested was made on the wheel, and the decorations applied mostly by means of a contrivance that looked something like a teapot with a small narrow spout. The slip was mixed to a thick flowing consistency and poured out in the form of a fluid outline.

A skilful user of this instrument can draw an outline of varying thickness and make all manner of shapes and spots, sometimes covering large surfaces.

The palette was generally limited to two or three colors, and the ware finished in a raw lead glaze stained with iron.

(*c*) **French Barbotine Processes.**—The French art potters produced cleverly executed naturalistic decorations in colored slips. The backgrounds were brushed over the surface of the ware, and the technique was identical to that used in oil painting. In some instances, the ware was baked before it was decorated, and in such cases a calcined slip was used as a base for the various colors. A number of English factories, Leeds, Wardles, Doultons and Mintons, also produced similar types.

(*d*) **European Craft Pottery.**—These were developments involving combinations of the early slip processes. Backgrounds were applied by

means of the blowing bottle, a contrivance similar to the teapot contrivance used by the Tofts, and by dipping. Some of the decorations were applied by means of the so-called tube process. This tube is a development of the

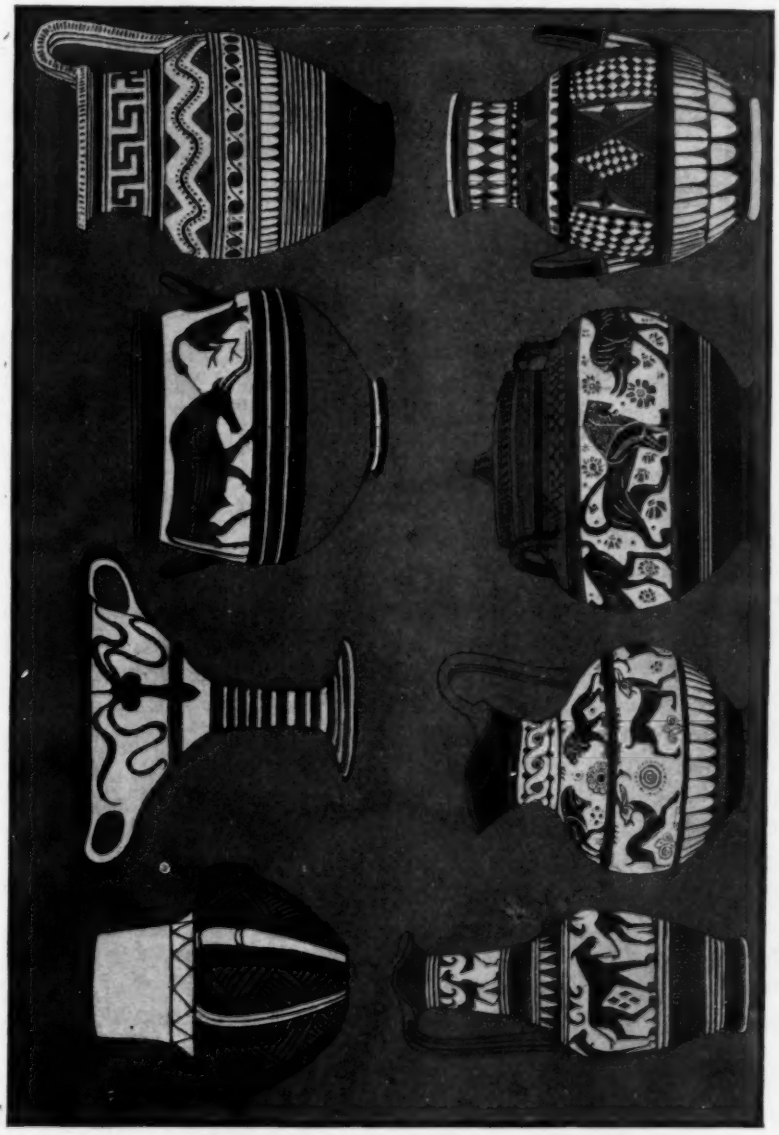

FIG. 3.—Early Grecian pottery.

blowing bottle and consists of a rubber bag, or a collapsible tube to which a glass or metal hollow point is attached. The bag is filled with slip and a slight pressure to the bag or tube produces a raised line corresponding to

the size of the opening of the point. This process has been used with considerable commercial success in connection with the production of both art ware and tile. Conventional designs were also painted on the ware in colored slips. The small art potteries in Devonshire, England have produced interesting examples.

(*e*) **The Rookwood School.**—The French naturalistic slip painted wares seem to have been the inspiration for the early Rookwood pottery, although there was obviously the policy and intention to develop a characteristically American product. The majority of the decorations were originally naturalistic in style, but the Rookwood decorators inclined toward a more highly finished technique rather than the bristle brush manipulations of the French and English slip painters. While the boldness and dash of some of the French examples may be admired, there is no doubt that the extreme delicacy of the Rookwood technique was more appropriate for the smaller pieces. Some writers have thought that Rookwood has been influenced by Copenhagen and contemporary potteries of like standing. The reverse might be just as likely because Rookwood has been developing her original processes for more than forty years, and has exhibited abroad at most of the foreign expositions since 1880, while the naturalistic slip decorations in porcelain of the Copenhagen school were not in vogue previous to the Paris Exposition of 1900. It seems more correct to assume that the best of the Chinese and Japanese porcelains have influenced not only Rookwood, but also the big continental factories producing naturalistic slip decorations in faience and porcelain.

(*f*) **Copenhagen and Sèvres School.**—These organizations also produced naturalistic slip decorations possessing a high degree of finish, but porcelain bodies were used, resulting in a transparency and delicacy not possible in earthenware or faience. Some of the examples are so delicate in treatment, and low in relief that they look more like underglaze painting on the biscuit. The colors are rich, but low in value because of the fact that the wares are fired to a high temperature, in some cases to cone 17. The Rorstrand pottery of Sweden has also produced fine examples in this type.

The best works of these concerns, together with those of Rookwood, can undoubtedly stand side by side without losing in comparison with the finest pieces of Kozan, Seifu, and other great Japanese pottery decorators.

(*g*) **Pate-sur-Pate.**—A process, which superficially speaking would be included in the modeling group, except that it is essentially a slip process, and not modeled in the plastic sense of the term. It is executed exclusively in porcelain clays. A slip ground is applied, and the design, generally a figure subject, is drawn on the surface. A white or contrasting colored silhouette of slip is painted within the outline, making the lowest plane in the relief. This is scraped perfectly level, and the next highest plane is

painted over the silhouette, scraped and graduated to the lower level, and so on until the highest planes are reached. The process involves both brush and tool work. The slips are naturally opaque before firing, and where the decorator desires transparent effects, he must use careful judgment and great skill in tooling his planes.

L. M. Solon of Sèvres, and later at Mintons earned an international reputation with his works in pâte-sur-pâte. The writer's father, Frederick A. Rhead, and a pupil of Solon produced a number of important pieces in this process at Mintons and later at Wedgwoods.

Taxile Doat, of Sèvres, one of the greatest decorative ceramists of today, used this process for a number of his more ambitious works. This country, and particularly St. Louis, is very fortunate in possessing some three hundred pieces of Doat's work.

4. Underglaze Processes

In dealing with descriptions of processes, one is confronted with problems of definitions and classifications due to misunderstanding and confusion resulting from misnamed and misleading trade names which have come into common use. In this country, underglaze work is commonly understood as referring to slip-painting, while in other countries it refers to decorations applied to the biscuit surface.

Slip decorations are done on the clay with stained slips, while, as stated, underglaze decorations are done on the biscuit surface with calcinations of the metallic oxides. At the lower temperatures, ranging to cone 7 or 8, the colors may be very deep and rich, and fairly wide in variety of hue. As the temperature increases, the yellows and reds are eliminated, leaving a working palette consisting mainly of blues, grays and greens. The colors are finely ground, and used with water and some gummy medium as in water color, or with turpentine and fat oil as in oil painting. There is practically no limit to its possibilities in technique. An artist can paint in the broadest possible manner, or he can do miniature work. For the commercial processes, printing, stamping with sponges, stenciling, lithography and even photography have been used in connection with underglaze color work. The Staffordshire printed dinner wares are typical examples of the commercial processes, while the Copenhagen, Delft, Italian and Chinese underglaze decorators have shown something of the possibilities in decorative work.

Types of Underglaze Decoration.

(*a*) Grecian vases.
(*b*) Persian faience.
(*c*) Italian, Spanish and Mexican faience.
(*d*) Japanese and Chinese porcelains.
(*e*) Staffordshire printed wares.
(*f*) Modern underglaze decorations.

Grecian Vases.—Perhaps these vases should be included in the slip painting group. But speaking from a ceramic painter's point of view it is an underglaze process. All slip work, except the highly stained high temperature porcelain decoration, is more or less in relief, that is, the color is applied as a body as in oil color, and not as a stain as in water color. While underglaze colors may be quite heavily applied, the color is generally flat. The Grecian vases are flat in decoration, and if duplicated today, there is little doubt that underglaze colors would be used. The pottery of the Hissarlik class and found in the northern islands of the Greek Archipelago resembles both in shape and decoration some of the early Indian pottery of this country. The Mycenaean, Dipylon, Phaleron and Corinthian wares are more elaborately decorated, the latter having borders of real and imaginary animals and birds. Some of the examples show a distinct Egyptian influence. While the body generally was a soft porous earthenware, numerous examples of porcelain have been found of the period of the seventh century B.C.

The black-figure period (sixth century B. C.) and the red-figure period (fifth century B. C.) both furnish magnificient examples of design and ceramic decoration. The fourth and third centuries B. C. marked the decline of Greek vase painting.

Persian Faience.—There is a wide difference of opinion in regard to the classification of Persian pottery. The issue has become confused by the fact that various writers on ceramics have expressed definite opinions which have not been backed by adequate technical and practical knowledge. Certain writers base their assumptions according to the original composition of the body, irrespective of the possible changes in the same body when it is subjected to varying degrees of heat. An example of ceramic work made from kaolin, feldspar and silica is certainly not porcelain until it is subjected to a temperature high enough to make it vitrified and semi-transparent. A composition that may be quite suitable for a faience or earthenware, may easily be a true porcelain if fired to a high enough temperature. While all clay compositions will not become semi-transparent, except possibly, when the mixture is melted to a viscous or fluid condition, most of them can be brought to a vitreous and non-porous condition. This may properly lead one to assume that porous or absorbent bodies are immature bodies, and that a finished ceramic work should be classified according to its final physical characteristics and not according to its original formula content.

Classification.—While the following classification may be questioned, the given terms are at least applied with some knowledge of the technical and physical elements involved.

FIG. 4.—Mexican majolica.

Terra Cotta.—Unglazed, opaque, porous or absorptive red or buff bodies.

Types.—Early primitive potteries, Grecian potteries, Tanagra figures, early Danish figurines, red floor tile, architectural wares.

Faience.—Glazed, opaque, porous or absorptive red or buff bodies decorated or otherwise.

Types.—Primitive, Persian, Italian, continental and English craft wares, Leeds, early Rookwood art wares, Rookwood and American encaustic architectural wares.

Earthenware.—Glazed, opaque, porous or absorbent, white, blue-white or cream, decorated or otherwise.

Types.—English and American non-vitrified dinner wares, Ruskin and similar art potteries.

Stoneware.—Glazed and unglazed opaque vitrified bodies, white or any color, more commonly buff or gray. Decorated or otherwise.

Types.—Early English salt glazed wares, German stoneware, Lambeth, English and American opaque vitrified dinner wares, chemical stoneware.

Porcelain.—Glazed or unglazed, semi-transparent, vitrified or semi-vitrified bodies of any color, decorated or undecorated, irrespective of kiln temperature.

Types.—Early Egyptian, Persian, Chinese, Japanese, English bone china, Belleek, Sèvres and similar continental types, continental and American semi-transparent table wares, chemical and electrical porcelain.

Such a classification would define pottery that is opaque and porous as either terra cotta, faience or earthenware, that which is vitrified and opaque as stoneware, and that which is semi-transparent as porcelain.

Persian Underglaze Decorations.—Underglaze decorations were applied directly to the body, and also over a white engobe. The combination of the rich alkaline glazes, somewhat heavily applied, with the sandy bodies, together with the brilliant contrasts in color resulted in a type that has never been equaled for richness and delicacy in effect. Even the best examples of other types of faience seem hard and uninteresting in texture when placed in direct contrast with fair examples of Persian faience. Some of the wares closely resemble the Chinese productions, and there is little doubt that the Chinese workmen who visited Persia exerted an influence for a considerable period.

Italian, Spanish and Mexican Underglaze Decorations.—Except for the difference in style and decorative treatment, it would be difficult to distinguish between the underglaze wares of these countries. Under this classification, I do not refer to the tin enamel or majolica processes which generally include the use of underglaze colors. I include only those wares decorated directly on the clay or bisque surface and glazed with a white or colored transparent lead or alkaline glaze.

The Italian type includes the so-called Mezza-majolica, and more slightly incised wares finished in underglaze colors, and the modern craft pottery. Cantigalli is a well known type, although a considerable part of this product is decorated over a tin enamel. Most of the true underglaze work in Italy seems to have been done previous to the best majolica period,

1500–1560, and later than the eighteenth century. Most of the pottery of Spain, Portugal and Mexico was also of the tin enamel type, but all three countries produced, and do produce, underglaze decorations on the biscuit.

Chinese and Japanese Porcelains (Chinese).—While the periods of the various styles and types of Chinese porcelains can approximately be determined, many experienced authorities admit their inability to tell whether certain examples were made during the period they are supposed to represent, or later. Examples of the Ming dynasty were certainly reproduced during the later periods and up to the eighteenth century, while during the Ming period, most of the earlier porcelains were reproduced.

Although this fact makes the actual identification of many examples difficult if not doubtful, the various types and processes can definitely be ascribed to the period of their origination and highest stage of development. Whether a particular example actually was made in this period, or later, is another matter, and does not concern the present discussion.

The first Chinese underglaze processes were without doubt the cobalt blue decorations which have been the inspiration for much of the continental blue and white wares of Delft and other potteries, and the English printed underglaze wares. Exquisite examples of these blue and white wares were produced under the Ming dynasty, and under the Ch'ing dynasty during the K'ang Hsi, Yung Cheng, and Ch'ien Lung periods. The highest stage of development was reached during the K'ang Hsi period. The designs were outlined with masterly precision and daintily shaded with lighter tones of the same blue used in the outline.

The backgrounds were variously treated. In some examples, the white ground of the porcelain was left untouched. In others it was broken by cross hatching as was done in some of the Hawthorne decorations, and again, the background was filled in with solid blue. Other colors and also colored glazes and enamels were used in combination with the cobalt blue, the more brilliant of these being applied after the underglaze decoration was glazed and fired. (The latter will be treated under the headings of Polychromes and Overglaze decorations).

The decorative motifs were as varied as their processes. Flowers, birds, animals, landscapes, figures, mythological and symbolical subjects, naturalistically and conventionally treated, were arranged over the most complicated and intricate areas not only with a consummate knowledge of design, but with a true craftsman's understanding of the possibilities and limitations of his material.

The Chinese ceramic artists (and they were artists in the highest sense of the term) developed a national and individual style which, with the Grecian, Persian and Italian potters formed the four great classical types which have influenced the ceramic work of all the other countries.

Japanese Underglaze Porcelains.—Burton gives the following interesting account of the introduction of porcelain-making in Japan: "The pioneer of Japanese porcelain was Gorodayu Go-Shonsui, who spent five years in China learning the art at Ching-te-chen. Returning to Japan in 1515 he made blue and white porcelain with imported Chinese materials; but as he was unable to find the necessary clay in Japan, his success was only temporary and left nothing but the knowledge of painting in blue under a glaze. The requisite materials, however, were discovered in the province of Hizen by a Corean named Risampei, about the year 1605, and forty years later two potters named Tokuemon and Kakiemon, with some help from a Chinese, developed the art of painting in enamel colors." The Japanese followed the Chinese processes and decorations quite closely and except for the difference in style, and for the more delicate, and perhaps effeminate (though none the less skilful) technique of the Japanese, it is obvious that the Chinese productions were the predominating influence in connection with the earlier and much of the later Japanese development.

There is little doubt that some of the softer effects were obtained by painting directly on the clay surface, and baking the pieces before they were glazed. When this is done, the colors, particularly the cobalt blues, will slightly stain the body and soften the edges of the masses of color.

Burton also states: "The Kioto potters did not turn their attention to porcelain until the end of the eighteenth century. Eisen was the first and he was followed by Mokubei, Rokubei, Eiraku, Dohachi and a number of other clever potters. The Seto factories, destined to be the most productive in Japan, owe their knowledge of porcelain-making to Kato Tamikichi, who penetrated the secrets of the Arita potters in the first decade of the nineteenth century."

Staffordshire Printed Wares.—Sadler and Green of Liverpool, England, are supposed to be the originators of printing on pottery in 1752, while Holdship and Hancock both claimed to have invented the process at Worcester in 1756. Brongniart states that printing was done in Marieburg in 1760. Whatever these facts may be, it is definite that Sadler and Green did develop the process independent of any other influence, and that Staffordshire potters, Wedgwood included, sent their wares to Liverpool to be printed and returned later to be glazed and fired. A number of the potters of this period made desultory attempts to execute the entire process on the factory, and Adams of Cobridge finally succeeded about 1775, after which time, Baddeley's, Spode, Wedgwood, Davenport, Ridgway, Enoch Wood, Minton and other manufacturers produced the printed wares which were the vogue for over one hundred years.

While ceramic printing is a comparatively simple process, it involves a considerable amount of preparatory work. The original design is carefully drawn and engraved in facsimile on a copper or soft steel plate.

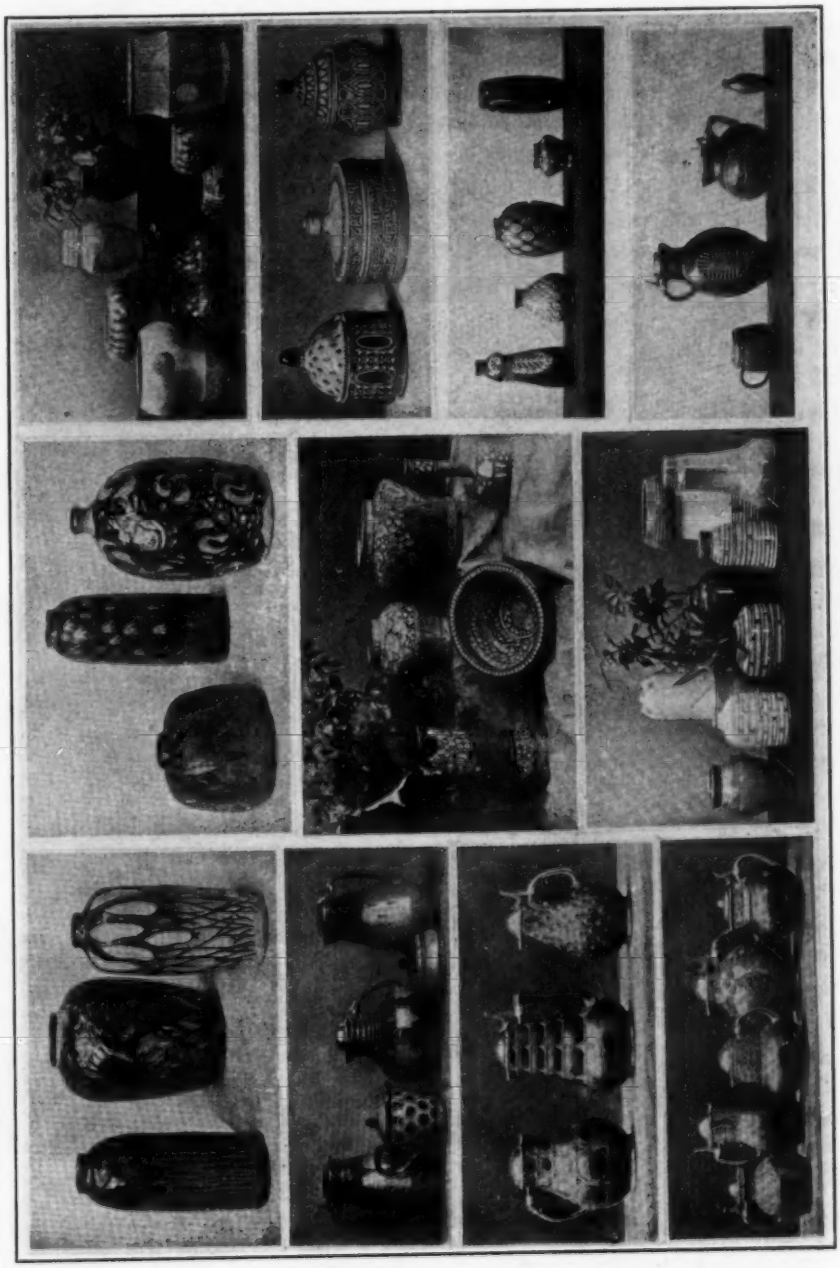

FIG. 5.—Modern German and Austrian craft wares.

The actual printing is done on a soft semi-transparent rice paper and transferred from this to the ware before the print is dry. The first printing was done with the roller hand press, but later a mechanical press was developed which printed the designs in continuous sheets which were cut up into individual patterns and arranged over the ware. Although the commercial and artistic possibilities have by no means been exhausted, the lithographic process has (temporarily, we believe) almost entirely replaced printing from copper plates.

The early printed designs were both oriental and pictorial in character, and as is usual during the development of a new decorative process the ornamentation was profuse rather than restrained. A dinner plate would have a heavy floral border, and the center would have a view of some public building or some historical scene.

The historical subjects included both domestic and foreign incidents, relating to peace and war, and portraits of famous characters. The early patterns were usually printed in blue. About 1830 other colors, black, brown, lilac and pink were used, and still later, the designs were considerably simplified, engraved mainly in outline and filled in with a number of other colors. However, the blue and white wares were the most popular at the time they were produced, and it is this class which is most valued by collectors of Staffordshire printed ware today.

Modern Underglaze Decorations.—In discussing modern underglaze productions the reviewer must take into consideration the influence exerted by the government art schools of the various countries. Previous to 1890 the manufacturer (with a few notable exceptions, such as Mintons) was content to ring the changes on the various historical types according to the pressure of competition and the demand for a change in style. Decorations were mainly naturalistic, or they were mechanical adaptations of foreign styles. But it is evident that the activities of the English Art Schools together with the active interest of such men as De Morgan, William Morris, Walter Crane, Coleman and others would result in a realization of the need for national decorative types. The English school of design was the predominating influence in Europe at this time, and quite creditable work was done by the art school students who were also apprentices in the factories. Underglaze decorating requires no equipment except the biscuit ware, colors and brushes, so the pieces could be taken to the schools, decorated under the direction of the design masters, and then glazed and fired at the plant. Here was a coöperation between school and factory that was bound to reflect to the benefit of the industry. The Paris Exposition of 1900 brought together the ceramic works of the various countries, and in the decorated types, a fair proportion were executed in underglaze colors. The English wares were of the Morris-Crane school, decorated on a white body, or buff and terra cotta bodies using white as an

opacifier. The French were at this time running wild with their abominable L'Art Nouveau decorations, while the Germans were just developing

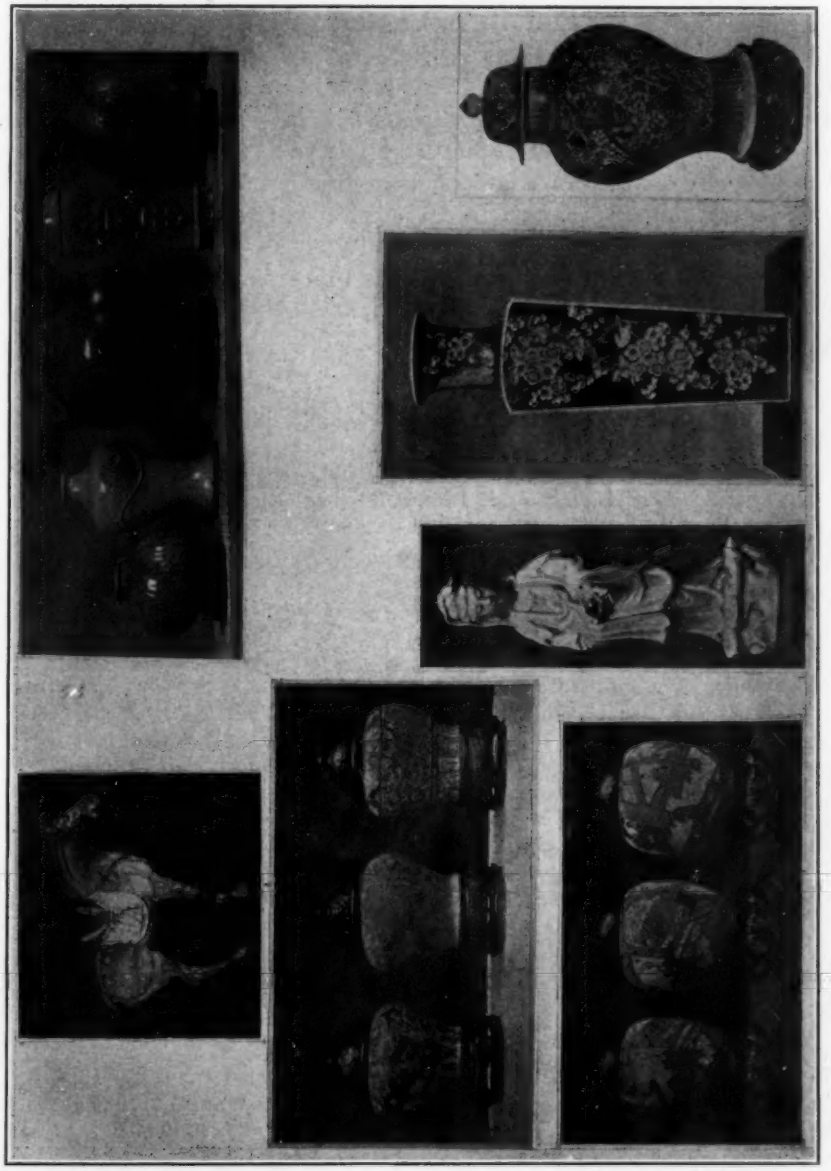

FIG. 6.—Chinese pottery and porcelain of various periods.

their heavy, stupid and elementary checker-board conventionalizations. Compared to the bulk of the latter productions, the primitive and even the archaic potters were masters of shape construction and ceramic design.

Notwithstanding these abortive and strained attempts at originality enough really good work has been done to show that the continental potters are really interested in the possibilities in ceramic decoration. Such men as Professor Max Lauger in Germany, Karl Klaus, Ernst Wahless and Professor Frommell in Austria, Arnold Krog of Copenhagen, Wallander of Rorstrand, Sweden, Laconte of Delft, Kok of Rozenburg, and Maurice Dufrene of France, however, are notable exceptions who have done much fine work in the underglaze, and other processes. F. A. Rhead, the writer's father, produced a big series of underglaze decorations for some of the leading art potters and tile manufacturers in Staffordshire.

5. Polychrome Glaze Processes

The polychrome glaze processes may be divided into the following groups:

(*a*) **Painting over Modeled Surfaces.**
Types.—Ming, Della Robbia, Palissy, Minton, English commercial art wares, misnamed majolica, and American modeled matt glazed wares in colors.

(*b*) **Flat Glaze Decorations with a Flat Outline.**
Types.—K'ang Hsi, Japanese, Persian, Modern, Rhead Pottery, California.

(*c*) **Flat Glaze Decorations with a Raised Outline.**
Types.—Ming, Japanese, Minton, Wedgwood and Moorecroft (England) Continental and American craft wares.

(*d*) **Flat Glaze Decorations with Incised or Sunken Lines.**
Types.—Japanese (Seifu), American Art Wares, Tile, American Encaustic Tiling Co.

(*e*) **Painting over Unfired Glaze.**
Types.—Persian, Italian Majolica, Delft, Mexican, American Encaustic Tiling Co.

(*f*) **Decorating with Juxtaposed Glazes of Different Colors and Textures.**
Types.—Modern tile decorations, American Encaustic Tiling Co.

(*g*) **Splashed, Mottled and Blended Glazes of Different Colors and Textures.**
Types.—Chinese, Japanese (various periods), French studio potters, Sèvres, Copenhagen, English (Ruskin, Pilkington, Minton, Leeds, Bretby, Bernard Moore, etc.), American (Binns, Rookwood, Robineau, Robertson, Walrath, and a number of craft potters).

Modeled Surfaces.—In the mind of the layman, painted glaze decorations are often associated with the majolicas of the Della Robbia type to the exclusion of other groups which should be included under this classification. When the potter commenced to use colored glazes, he would naturally try them out on whatever type of pottery was available whether it would be suitable for the particular treatment or not. We have examples of polychromes of most of the early potters of various countries, but nearly always over modeled surfaces.

With many glazes it is a delicate proposition to attempt to paint on flat surfaces. Aside from the tendency of such glazes to flow, there is the

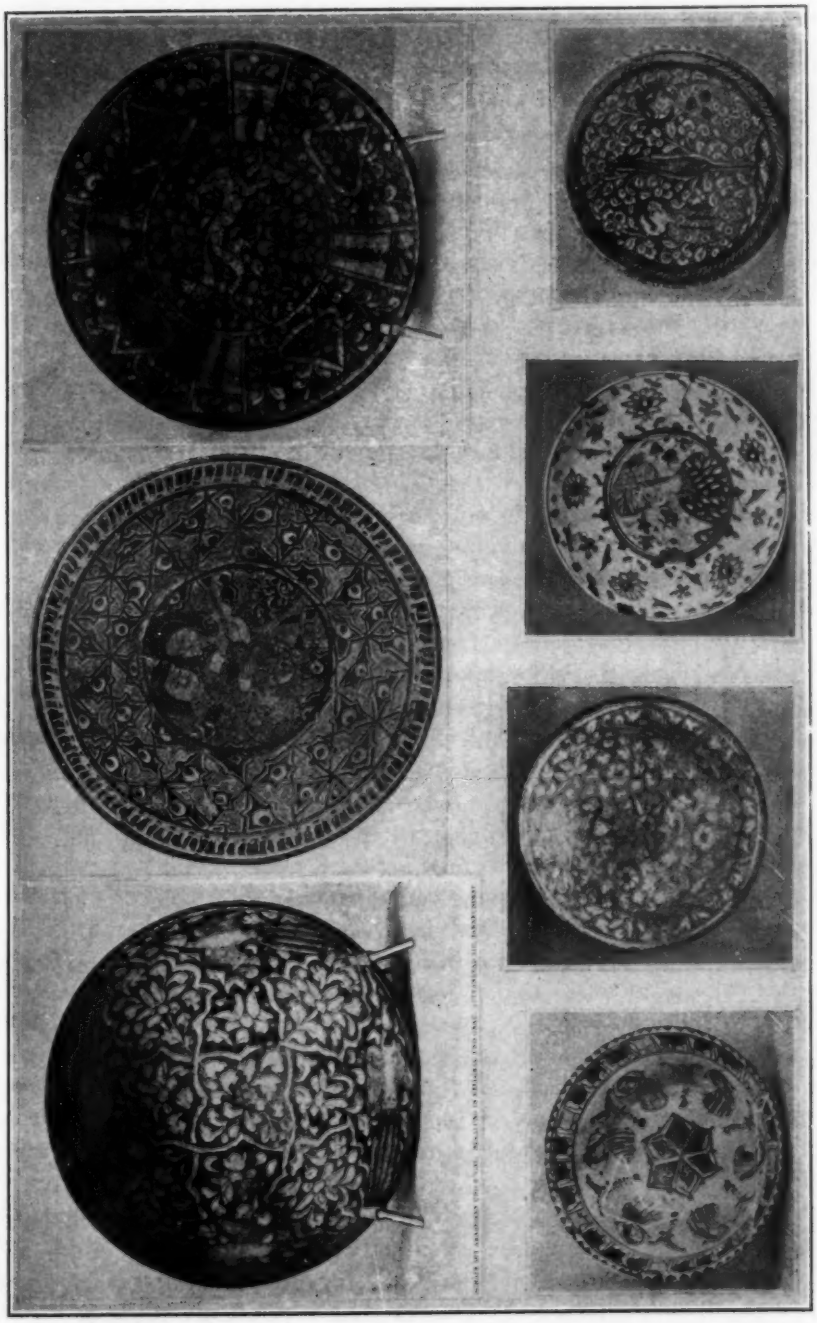

FIG. 7.—Persian luster wares.

additional tendency to run into those glazes in juxtaposition, a property which has been used to great artistic effect in many types of ware. Not all glazes will flow, however. Tin enamels, tin, zinc, some of the alumina and fritted matts, and a number of the higher temperature felspathic glazes do not as a rule flow very much, and a number of these may be applied in juxtaposition, or on the top of one another without either flowing, or losing the detail of the design. But the lower temperature lead and alkaline glazes, the crystalline series, and most of the transparent enamels flow very readily, especially when applied on upright surfaces.

The method generally adopted for the painted glaze processes is to provide some means of separating or confining the various masses. In some of the early modeled wares, the glaze was either applied so thin that there was not enough mass weigh to flow, or there was a total disregard of the flowing properties of the glazes. There are examples of Ming porcelains of both types, and the early English Whieldon ware shows an effective use of two or more colors flowing into one another over modeled surfaces.

While as stated, tin enamels do not readily flow, the Della Robbia's modeled their panels with a definite glaze treatment in mind. The various masses and details were clearly and beautifully defined, and so arranged that a deep blue of a drapery, for instance, could not easily flow over, or stain the white enamel of a face, hand, or foot. In some of the Ming pieces, the glazes would be applied in such a manner that they would slightly overlap one another, resulting in soft and indefinite edges to the masses of color.

The English commercial colored glazed wares were decorated with washes or applications that were not heavy enough to flow to any great extent. The American art potters cleverly avoided the undesirable effects of flowing when heavy masses of glaze were required, as in the case of many of the matt glazes, by arranging their designs vertically over the shapes. The vertical leaf designs of Grueby, Rookwood and Teco are typical examples.

Flat Outlines.—The potters of the K'ang Hsi period used an outline of underglaze color or metallic stain. There are a number of possibilities in connection with flat outlines. Not only can various colors be used for this purpose, but different effects can be obtained by varying the thickness, or width of the outline. The masses of glaze may be applied just to the edge of the outline, or, if the line is wide enough, the glaze may slightly overlap the edge, but not enough to touch the adjoining mass of color. An outline may be clear and definite, or it may be soft, and become partially or almost wholly absorbed by the surrounding masses of glaze. Black oxide of manganese finely ground makes one of the most satisfactory outlines for such work. It is a soft but lustrous brownish black, and when solidly applied will hold quite a heavy mass of glaze in position. An inter-

esting effect is also obtained by adding about ten per cent of black oxide of copper to the manganese. This will result in a slight greenish stain along the edge of the outline, and it is most effective where light color schemes are used.

Raised Outlines.—A raised outline may be produced in the mold of the piece; it may be applied with a brush (a rather slow and laborious method), or drawn over the shape, or surface, with the tube which was described in the section on slip processes. In the two latter methods, the outline may be in any color, but in the molded line, it would be of the same color as the clay body. In tile, and faience wares, where a dark molded line is desired, a red body is often used. Where there is considerable background, the piece may be dipped or sprayed with the background glaze which is scraped off those portions requiring another color. These details are then applied with a brush. When the decoration is broken up over the surface with little background space, the brush is used altogether.

Many fine examples of garnitures, and other ornamental pieces were decorated with glazes of aubergine, green and blue, and the masses separated by means of a white raised line, by the potters of the Ming and early K'ang Hsi periods.

The Japanese have also used this process. The raised line in the above instances was produced with a brush, and by the very laborious method of carving away the background with the exception of the raised boundary around the masses of glaze. Judging from the rounded and spontaneous quality of the outline of some specimens it is fairly definite that an instrument similar to the slip tube was also used.

The raised outline work has been a popular commercial art process for a number of years. Mintons used it with good artistic effect, and a brother of Frederick Barnard, the well-known illustrator of Dickens, introduced this process at Wedgwood, and later at Mcintyres of Cobridge, England. Moorecroft succeeded Barnard at Mcintyres and produced some cleverly designed semi-naturalistic decorations. The continental art potters have used this process extensively, and it practically became a standard decorative type among the tile manufacturers in England, on the Continent and in this country.

Incised or Sunken Lines.—The incised line has been more often used directly over the clay surface, in connection with the sgraffito processes, or with the slip processes.

Because of the tendency of many of the glazes to flow, the ceramic craftsman has avoided sunken lines in connection with polychrome glaze processes. But curiously enough, an incised line is one of the safest outlines for this purpose. A glaze that is excessively fluid will flow to the edge of a sunken line, and then stop unless the glaze is too heavy, or the kiln

temperature too high. For this reason, and also because floor decoration should be flat, the incised outline is most appropriate for polychrome treatment for floor tile, and it is being generally used with commercial and artistic success by the tile manufacturer.

Painting over Unfired Glaze.—Glazes which can be used as unfired backgrounds for decoration are generally such non-flowing types as tin enamels, non-crystalline matts, and the higher temperature felspathic

FIG. 8*a*.—Italian faience underglaze painting over tin enamel.

matts. Transparent glossy textures, raw lead, fritted lead and alkaline glazes are almost entirely flowing glazes, and as such cannot be used for backgrounds, or for decoration over other unfired glazes if clear detail is required. As a rule, if a glaze is suitable for a background, a color palette made up of the background base glaze is also suitable for the applied decoration. But this does not mean that various types of glaze cannot be used on the same piece. For instance, a vase or tile panel

can be glazed all over with a green tin enamel, and after the design has been sketched or stenciled over the unfired surface, the colored glazes, which may include colored tin enamels of the same type as the background glaze, matt glazes and even transparent glazes may be applied in such a manner that the original detail will be retained after the piece is fired. It is possible to obtain clear and sharp detail as well as soft blended effects. Glazes of soft rich texture can be applied over harder and lesser flowing glazes, or the reverse, with excellent artistic results.

If soft readily flowing mixtures are used, the detail will almost entirely disappear because the applied glazes will be absorbed into the background; or, in the case of an upright shape, the decoration will run down the piece,

FIG. 8*b*.—Modern English luster wares.

forming a streaked effect which will be more or less blended according to the softness of the glazes and the kiln treatment.

Generally speaking, glazes which mature at the same temperature should be used for the same decoration, although a decorator with sufficient knowledge of his material can successfully use glazes of widely varying types and degree of maturity on the same work. Or, for instance, a cone 10 felspathic matt may be applied over a cone 3 tin enamel if the applied masses are not too large to become partially or wholly fused into the background mass at a cone 3 temperature. In using glazes of a wide range in temperature, the lowest in range should be the background glaze, and the firing temperature adjusted to this particular glaze. If a cone 1 glaze is

used over a cone 8 background, the temperature required to mature the background will in most cases burn up the decoration.

It is well to bear in mind these conditions because many of the interesting effects by the early potters were obtained by means and combinations which would not be considered practical or possible by the technician of today. While an industrial process must exclude as far as is possible many variable elements which can to an acceptable extent be controlled by a skilful craftsman, it must also be remembered that the orientals were not technical men as we understand the term, yet we have produced few ceramic works which can compare with those of the potters of Persia and China.

The Persians decorated over an unfired glaze, but they used underglaze colors for outlines and the sharper detail. Copper green, cobalt blue, iron and manganese browns would be used as stains for the overglaze which would be floated or tinted either before or after the underglaze treatment was applied over the background glaze. Sometimes the completed decoration would be given a thin coat of transparent glaze which would increase the brilliancy of the color and texture. In such instances, the decoration consisting of colored glazes and underglaze colors would be sandwiched between an opaque enamel background and an overglaze of transparent glaze.

The Italian majolica of the Gubbio type was decorated with underglaze colors over the unfired tin enamel, with an occasional overlay of transparent glaze. In modern practice this process has been confined to work on flat tile. One method which has been found practical for quantity production is to stencil the glaze decoration directly on the clay unglazed tile, afterwards dipping it in the background glaze, which in this case would be transparent or semi-transparent.

Except where simple treatments are concerned, decorating over unfired glazes is essentially a craftsman's process, and while it has great artistic possibilities a considerable knowledge of technique is necessary to obtain reasonable and consistent results.

Decorating with Juxtaposed Glazes.—There are two methods of applying glazes in juxtaposition. One is to dip the piece all over in the background glaze and then scratch out the decoration which is to be filled in with the other glazes; and the second method is that where the design is drawn over the shape, and the background and decoration applied with a brush.

Tile and flat surfaces are most appropriate, and as with the process just described, the glazes used must be those which will not too readily flow or run into one another.

Splashed, Mottled and Blended Glazes.—Splashed and mottled effects were, originally, undoubtedly the result of the manipulations of the early

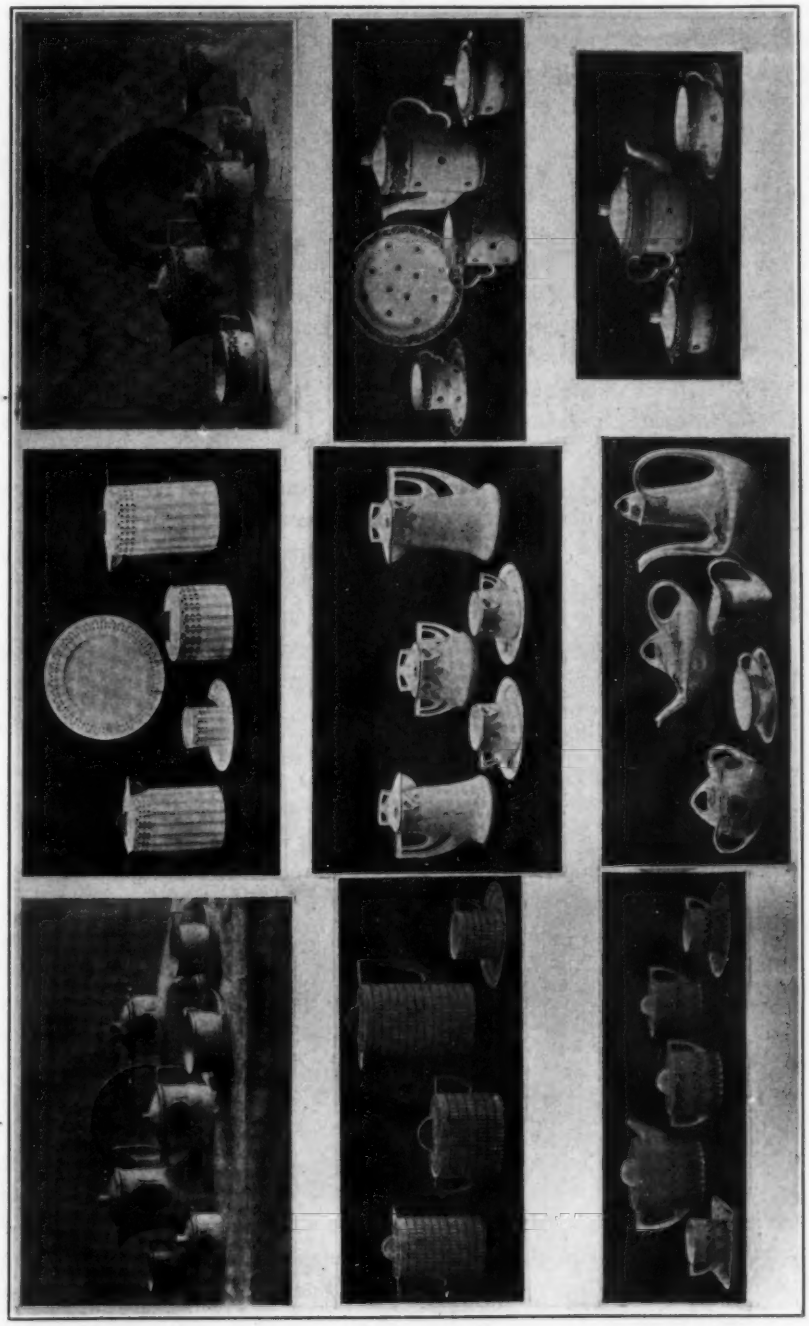

FIG. 9.—Modern German and Austrian tablewares.

potters in doctoring those monochromes which were unsuccessful in the first fire. Most of the early Chinese pieces, for instance, were made on the wheel, often requiring considerable work. If for any reason a second application of the same glaze would not correct the defect, a glaze of another color would be splashed over the surface. In some cases where different colors would be used for the inside and outside of a vase the inside color would run over the edge and blend into the outside color and thus suggest possibilities for further development. The method of manipulation depended on the type of glaze used. Readily flowing glazes would suggest bolder treatments than those where non-flowing matts and enamels were used. In the former case, the unfired piece would present an altogether different appearance to the finished result. A flowing glaze that is sponged or splashed around the top of an unfired glazed piece will run all down the shape if the application is heavy enough. The glazeur can produce an approximate effect with some degree of certainty, but he cannot exactly reproduce a definite marking.

With non-flowing glazes, however, his conditions are subject to a greater degree of control. With atomizers of various sizes, or by spotting with his brush, he can mark or soufflé over a matt or enamel with copper, manganese or any of the metallic stains or even with glazes, and be reasonably sure that the effect will be retained after the piece is fired.

Practically speaking these processes are very simple, and while interesting effects are comparatively easy to obtain, it requires an artist to produce really beautiful and altogether satisfactory results.

6. Monochromes

It will be conceded by most collectors and connoisseurs that the most beautiful individual pieces, and certainly among the most prized are the monochromes. They certainly are the most difficult to produce. A skilful glazeur will cheerfully attempt a complicated piece of decorative glazing and be reasonably sure of a creditable result. But in attempting a series of monochromes he is never sure that he will get fine textures, or unblemished surfaces. Throwing and turning, pressing and casting, each have their particular body faults which may not be visible if the surface is broken up with decoration, but which may be plainly seen on a monochrome. The possible glaze faults are innumerable. Careless, or unskilful preparation of the glaze, the wrong method of application, imperfect firing, all contribute to the unsatisfactory result, or in other words, it is the perfect coördination of all the elements concerned that produces the perfect piece. The potter is often asked why he cannot, or does not produce examples in plain glazes that are as fine as the monochromes of the later Ming, or K'ang Hsi periods. Broadly speaking, the answer lies in the fact that we are living and working in an industrial age, while the early

potters lived in the craftsman's age. It is true that we have craftsmen who are doing sincere and earnest work. But these men are not as skilful as the early potters. They did not go through the severe apprenticeship

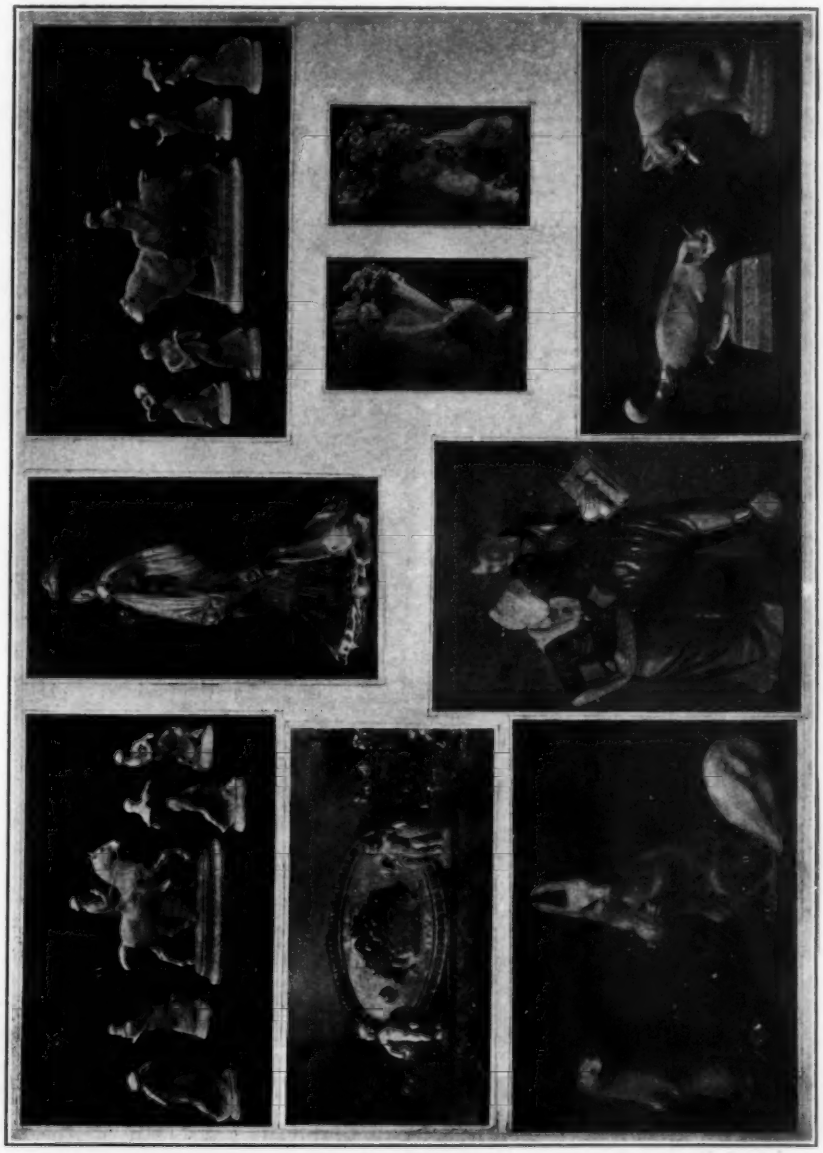

FIG. 10.—Modern faience and porcelain figurines.

that was compulsory during the best periods of ceramic development. In this industrial age, we have been trained to believe that the actual making of a clay form consists of little more than the mere pouring of slip

into a hollow mold, a process occupying a few minutes at most. If the piece is made on the wheel, it is either a process which must more or less compete with other commercial processes, or if the potter is a craftsman operating his own studio, he either does not possess the high degree of skill, or he is obliged to turn out so many pieces per day irrespective of the degree of finish attained. The modern potter in making his shapes, does not give anything like the same amount of thought and study in regard to their construction as was customary among the early potters.

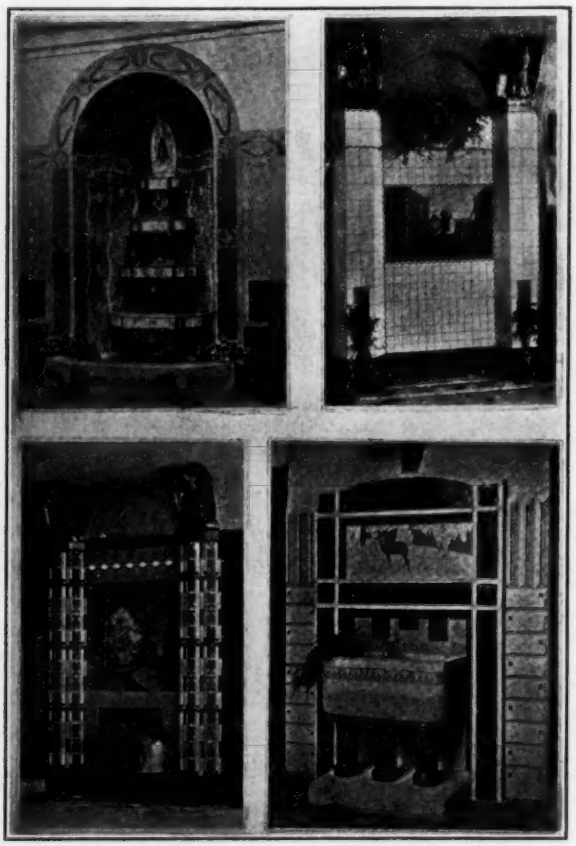

FIG. 11*a*.—Modern German and Austrian tile and architectural faience.

The two great ceramic shape construction developments are readily distinguished in the Grecian vases and in the Chinese vases, two totally different types, designed altogether under different conditions. The former were practically geometrical constructions, if we are to accept the analysis of Professor Hambidge in his scholarly attempt to discover the technical methods of the Greek designers (see the "Dynamic Symmetry

of the Greek Vase," by Jay Hambidge), while the Chinese vases were wheel manipulations of potters who were guided by an unerring instinctive taste for beauty of contour and form.

The Grecian vases are the forms of the sculptor and the architect, while the Chinese vases are the shapes of the true potter. Both are beautiful and perfect, but the latter are the logical and natural products of the potter's wheel, in fact the shapes could not have been originally developed by any other process. The Chinese potters gave the same care and study

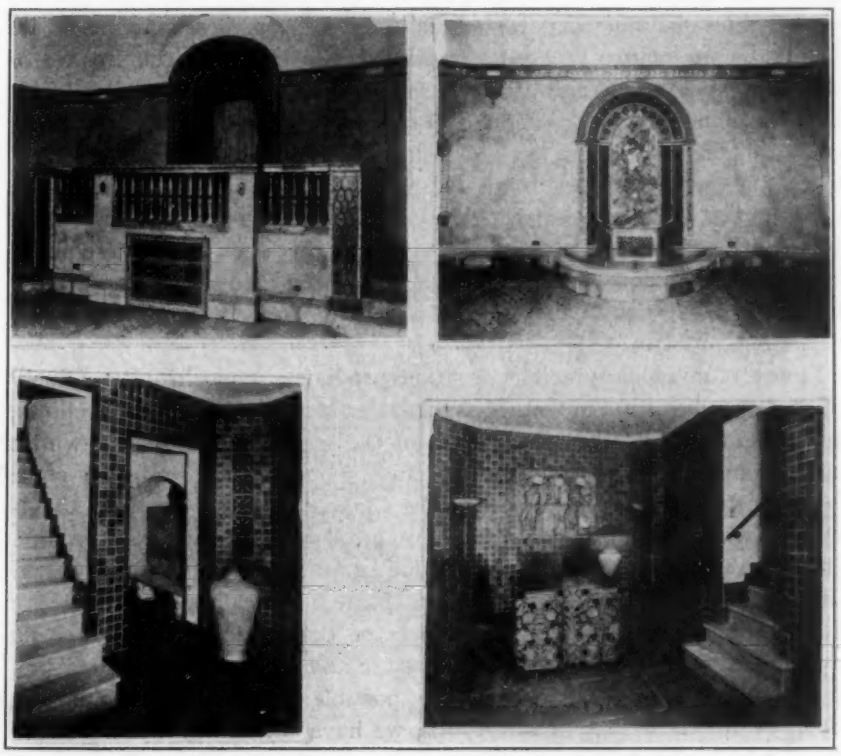

FIG. 11*b*.—Modern American architectural faience. American Encaustic Tiling Co.

to the glazing of the vases as they did to the making of the shape itself. It was not a matter of simply dipping the piece in the glaze tub, and scraping or cleaning off the base rim. Each piece received individual attention. If a flowing glaze was to be used, the amount of flow was fairly accurately estimated, and the glaze applied with a brush, heavier at the top, shoulders, and over any projecting place from which a certain amount would flow. The pieces revolved on a wheel while they were being glazed. From a craftsman's point of view, a glazed piece was a work of art even before it

was placed in the kiln. Dipping is a purely commercial process. It is the logical glazing process for industrial work, but however skilful a dipper may be, and however much care he may give to a series of monochromes, he can never attain the same quality of finish or control that is possible by brushing or spraying. Any potter or craftsman who has practiced both methods to any considerable extent can testify to this. Of course careful glazing by either the brushed or spray method is rather slow and laborious work compared to dipping. On the other hand, painting is slow and laborious when compared to photography and printing. If there are potters and art ware manufacturers who cannot easily accept these statements, let them take one or two of their best plain glazed pieces to the Boston or Metropolitan Museum and compare them with typical K'ang Hsi and Ch'ien Lung monochromes, taking note of their purity of form, beauty of finish, quality of texture, and richness of color. These qualities were not accidental, neither were they freaks of the fire. They were the result of hundreds of years of earnest development and concentration. With these facts in mind it is not difficult to realize why even an average bit of Sung, K'ang Hsi, or Ch'ien Lung will realize hundreds of dollars while a modern monochrome at fifty dollars is a rarity, or almost an impossible marketing problem.

I know of no modern factory or studio producing monochromes as finely finished or as beautiful in texture as the latter Ming, and K'ang Hsi yellows, turquoises, rusts, flambés, and others of the copper series, blacks, whites and a number of others, although the Japanese have produced some finely finished single glaze pieces. The Chinese as a rule confined themselves to mirror glazes, but they have produced surfaces of varying texture. Their iron rusts are often quite matt, and beautifully smooth to the touch. There are a number of beautiful matts, some of them having the texture of old parchment, eggshell, and others of the fruit skin variety. To properly classify glazes in regard to texture and color would be a big job. A collection of cabinet pieces of every possible variety would fill a large room. Considering the broad groups, we have white, black and colored glazes, which sounds like a simple and definite classification. But I have seen fifty different whites in one collection of Blanc-de-Chine glazes, all lighter in color than ivory or cream. The same might be said for the blacks. One could produce blacks for a hundred years and produce an amazing variety of texture and hue. Very few ceramists are aware of the possibilities in connection with combinations of metallic stains when used in proportions of ten per cent and over. I have dabbled with blacks for nearly ten years, and I know the subject is an inexhaustible one. Then consider the subject of texture. The first glaze developments concerned protective coverings for the clay surface. Then came transparent and opaque glazes of various colors. Developments of freaks of the fire and

speculative formula mixing accompanied rational glaze construction. Crackle glazes, a development of underfired felspathic enamels, flambés, a development of uncertain firing conditions, rusts and crystalline textures, developments due to the overloading with metallic oxides or experimenting with new materials have all contributed to present accomplishments and to the realization of new possibilities.

With all our present knowledge in ceramics we know very little about the monochrome and very few of us know how to make them.

7. Luster Processes

Most of the luster processes depend on the reducing atmosphere for the development of the iridescent surface and color. A typical method would be that revived by Massier. An alkaline tin glaze would be employed and matured in an oxidizing temperature. The glaze may contain copper, or a combination of metallic oxides. The fired piece is then decorated or splashed with a mixture of ocher, or combinations of other earths, and copper, silver and bismuth, with vinegar as a medium, and then subjected to a reducing atmosphere.

On coming from the kiln the ochreous mixture remaining on the surface is cleaned off, leaving the iridescent decoration. If an undecorated surface is desired, the mixture is painted or sprayed over the shape in a flat even coat. An irregular application, or a splashed or mottled coat of varied ochreous mixtures will produce an irregular surface.

The commercial metallic lusters on the market are applied over the glaze, as in china painting. They can, however, be used in connection with tin enamel decorations, the underglaze processes, and other decorative types. There are many possible methods and manipulations in luster work. The Persians, for instance, would decorate a bowl in underglaze colors finished in one or more colored glazes, adding the luster after the piece was fired. This treatment, of course involved a special firing for the luster. Often no luster was applied, the reducing atmosphere being responsible for the iridescence. In some examples the iridescence was not apparent when the pieces first came from the kilns, and only appeared after many years' exposure to the elements. In others the luster was caused by the action of the earths in contact with wares which have been buried for a considerable period. There are many fine examples of Italian majolica which have been finished in luster. Maestro Giorgio of Gubbio was famous for his luster decorations and often finished the majolica works of other decorators after the tin enamel decorations had been fired. Both the Persian and Italian overglaze lusters were the turpentine-metallic solutions which developed in an oxidizing atmosphere, and which are very similar to the lusters used in the china painting processes of today.

8. Overglaze Processes

The various overglaze processes are too well known to need much comment here. It is perhaps enough to state that it was inevitable that the potter would discover palettes of color and methods of decoration which would permit a wide range of hue and which would not be subject to extreme mechanical and chemical changes in the kiln.

All overglaze work, as the term implies is done over the glaze after the piece has been fired. The decorated ware is fired at a lower temperature than that involved in the production of the shape, or just enough to fuse the colors into the glaze. A wide range of colors has been developed in addition to gold, silver and the various lusters. The original overglaze work was no doubt the result of the potter's recognition of the limitation of the underglaze and the other processes together with his tendency to develop more highly finished decorative effects.

The Chinese decorator finding that he could not produce certain complimentary colors by the underglaze process naturally resorted to the overglaze method, applying the reds, pinks and gold after the underglaze decoration was completed and fired. The Italians did the same thing with their lusters, as previously noted.

The overglaze process in its highest development is typically European. The French, German and English decorators have executed works which are marvels of technique. Pastes have been developed in order to do relief work in gold and the other precious metals. Jewels have been applied and fired to the surface of the ware, and etching has been done by means of acid resisting grounds and hydrofluoric acid. Overglaze printed decorations have been in common commercial use, and to a small extent even photographic processes have been used in connection with overglaze decorations.

Today the great bulk of commercial utilitarian ware is decorated by the lithographic process, and there is little doubt that this will be the standard commercial process for many years to come, although it is to be hoped that the copper plate printing process will be revived because there are many decorative effects which have not yet been developed, and which cannot be produced by any other process. In recent years the overglaze process has deservedly sunk into disrepute, although there will always be more or less good work done because this medium is an essential to certain types of ware.

9. Ceramic Sculpture

The most superficial survey of the existing works which may properly be classed as ceramic sculpture must impress the reader with the artistic possibilities of this branch of ceramic art. It is only necessary to refer to the terra cottas of the Aztec, Egyptian and Grecian periods of the Tanagra

figures, the delightful and beautifully modeled figures of the Han and T'ang dynasties, and later, the exquisite porcelain figures of the Ming and K'ang Hsi periods. The Japanese have also been responsible for some

FIG. 12.—Majolica panel executed by American Encaustic Tiling Company.

finely modeled works both in earthenware and porcelain. The European potters have almost always been interested in ceramic sculpture. The

Adams, Wheildon, Wedgwood, Spode and a number of later potteries have produced examples adequately demonstrating possibilities. The figures of Sèvres, Berlin, Dresden, Copenhagen, and the early Staffordshire figures are well known to the collector and connoisseur.

The sculptor has always been interested in the possibilities of faience and porcelain, but he has not been successful in obtaining the active co-operation of the potter.

Ceramic material possesses at least equal opportunities for the sculptor as marble, bronze and ivory. He is aware of this, and it only remains for the faience, earthenware and porcelain manufacturer to realize the commercial possibilities (for indeed there is an immediate and remunerative market for such work) and to coöperate with the sculptor in bringing about conditions where sculpture can be successfully executed.

There are three general methods by which ceramic sculpture can be made: (1) by firing the original model, (2) by casting, (3) by pressing.

If the subject is to be executed in terra cotta, faience or stoneware, and only one piece is needed, the original clay model may be fired providing a satisfactory clay is used and assuming that provision is made to remove the armature, and to otherwise adjust conditions so the subject may be fired without the risk of cracking or becoming distorted in the kiln.

The piece may be solid or hollow. If it is solid, the sculptor must use a sandy open clay subject to slight contraction, and he must be sure that the clay core is tightly put together and altogether free from air spaces.

Many of the Han and T'ang horses and other figures were the original models. The armatures of some of these pieces were of wood with straw or fibrous cores which burnt out during the fire. Openings were made at the base or in inconspicuous places to permit combustion and the escape of gases. The writer once repaired about twenty fine Han figures which had been badly smashed during shipment from China. All of these had been modeled around wooden and fibrous armatures which in a number of pieces had not been completely consumed.

The more delicate and intricate subjects, especially those made in porcelain are cast.

Large terra cotta, faience or stoneware figures are pressed. The most important essential next to that of appropriate technique in modeling is the correct type of mold. It is obvious that the sculptor in modeling for the ceramic process will consider the nature of the material. But however simple his subject, there will always be difficulties in mold-making and in getting a satisfactory reproduction in clay from the mold. Undercuts must be provided for either by means of slides, or by filling up those places which will not draw, and afterwards cutting away these additions. The latter work should always be done by the sculptor himself because there are always effects which cannot be obtained by means of the mold.

There are certain types of modeling which cannot at all be reproduced by means of the plaster mold, and the only solution for such works is the use of the gelatin mold which can be pulled away from the reproduction without

FIG. 13.—Arabian court in the house of the late Sir Frederick Leighton, London.

injuring it or tearing away overlapping details. This type of mold is used by the Italian plaster workers and it has been used by Conrad Dressler in

connection with his beautiful ceramic reliefs. But whatever method is used the condition must be one where the potter is working with the sculptor. It is impossible to do satisfactory work, for instance, under conditions where a subject is modeled five hundred miles away from the factory by a sculptor who has no knowledge of ceramic processes, and produced in a plant without his supervision or direction. It is a big undertaking to produce ceramic sculpture either in figurines or larger pieces. But there are many tangible signs that such work is going to be done in this country within the next ten years.

10. Architectural Pottery

Architectural pottery came into being at the time the primitive was aware of the plastic nature of clay and its hardening properties when subject to enough heat to expel the chemically combined water.

The period of national development depended on the state of the development of the particular country, and other conditions pertaining to available material and prevalent decorative interest. In those countries where stone and marble were readily procured, there developed a style of architecture suitable to these materials.

Sources of supply, local conditions and expediency were the general determining factors then as now.

Previous papers on this subject have appeared in this *Journal*, and we are about to publish a most valuable paper by Mr. Dressler on the possibilities of architectural faience, so it is not necessary for me to give an extensive historical outline. What I have to say at this time relates to present conditions in this country.

It would be grossly untrue and unfair to state, or imply that the terra cotta and faience manufacturers were not seriously attempting to develop the art to the point where we can rank with the best that has been done. Too much has already been accomplished in this country, and on a scale never before attempted, to question the fact that we are adequately preparing ourselves for the production of architectural work such as the world has never seen.

We may not have produced a porcelain pagoda, a Taj Mahal, a Della Robbia relief, or even a Petit Palace, but technically or practically speaking, we are (and have been during the past twenty years) producing architectural wares on a scale, and in a space of time which would have astounded the potters who were responsible for these earlier works held up for our example.

Present commercial conditions will not permit our spending from twenty to thirty years in the erection of a single building. A forty story structure must be completed in a few months, within a year at most, and naturally, the result is in accordance with present requirements. The Spanish galleon

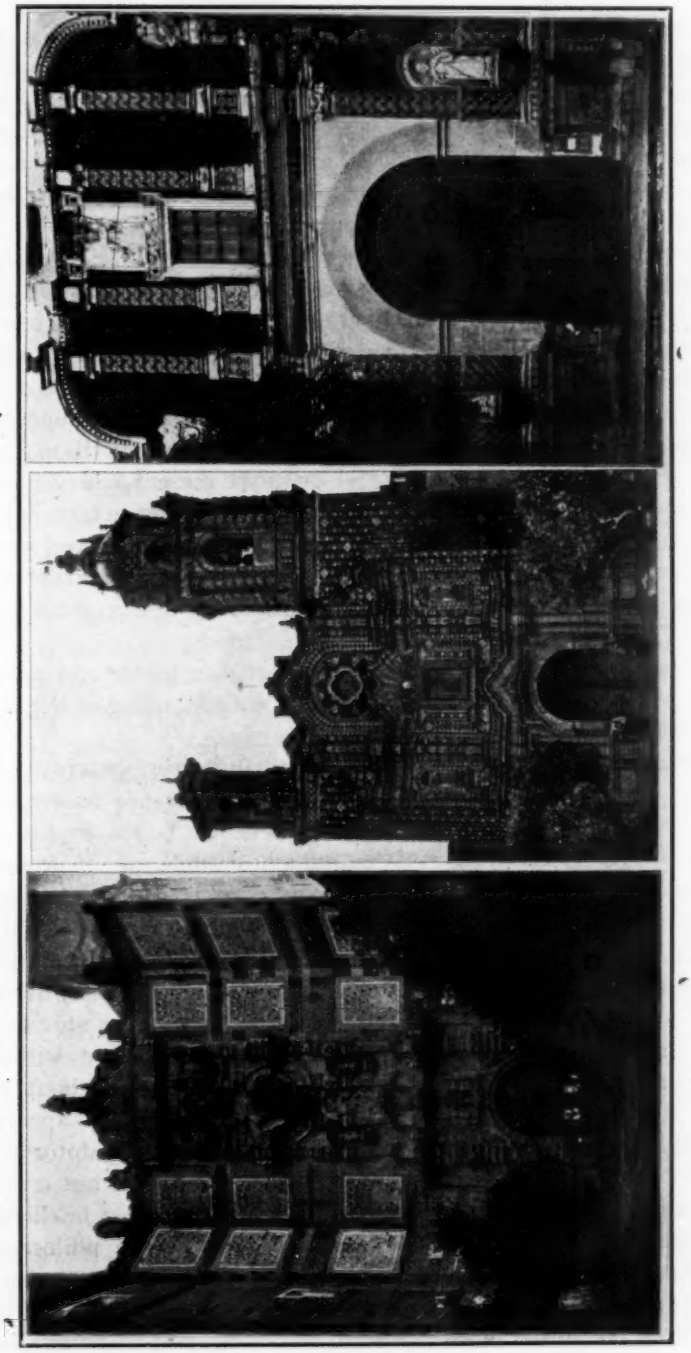

FIG. 14.—Mexican churches showing majolica tile and faience treatments.

may be more picturesque than the present day ocean liner, but it would be a poor substitute; and there is no question which ship the sensitive critic would select for an ocean trip. The old adage that beauty is only skin deep may certainly be applied to some of the old masterpieces. While I am able, I think, to appreciate the visual glories of the Italian palaces, I know that I prefer to sleep in an American hotel and reside in a typical American home. Both these institutions are equipped and furnished with ceramic wares that could not be produced by the early potters. Our architects are concentrating on the fundamentals of service and comfort which were, comparatively speaking, non-existent in the good old days. And in this we are only following the precedent adopted by our ancestors, the primitives, who only commenced to think of decoration and embellishment after the necessities (as they understood them) had been adequately provided for.

As stated, we are thinking seriously of the beauty of our surroundings, and our architects and craftsmen are as much concerned as were the masters of the Renaissance and other periods. So far as the present achievements of our potters are concerned, it is only necessary to note that in terra cotta, tile and faience development, we are now leading the world. And we at this time have arrived at the stage where we realize that the artist and sculptor must be given a more important part to play in large scale production.

The only way to accomplish this is for the artist, sculptor and manufacturer to get together and come to a common understanding of the conditions involved.

The artist and sculptor must realize that the manufacture of terra cotta and tile is a business undertaking and not a millionaire's hobby. A capitalist will not invest in a proposition unless he can be reasonably assured of dividends. Neither will a clay manufacturer undertake to produce artistic terra cotta and faience unless it will earn a profit, and as a business undertaking, it must be subject to the same control as any other productive activity. It is not the slightest use for the ceramic artist to attempt to produce under the same conditions as were prevalent, for instance, during the erection of St. Marks, because modern industrial activities are vastly different. No important construction activity is undertaken without first estimating approximate cost and time involved, and without the creation of an organization which will efficiently direct and supervise the undertaking. This does not mean that the artist or sculptor is a machine, or that he must work under unfavorable conditions, but it does mean that aside from his skill as an artist he must possess an intelligent understanding of the industrial conditions of today. The philosophy holding that an artist or craftsman is a being entirely apart from the business man is as archaic as the science of medicine in the time of Gil Blas. But the artist is one of the most important essentials, and however much

practical and technical skill may be employed and however elaborate the job may be, it is impossible to coördinate the various decorative developments without his assistance and direction.

If the artist can accept his obvious opportunities, and if the manufacturer can realize that he cannot manufacture artistic products unless he utilizes the services of competent artists, it will not be many years until American ceramic wares of every nature are shipped all over the world.

But the terra cotta manufacturer must remember that his wares are just as artistic as his artists are capable of producing. The judgment of a work of art is not a matter of opinion, although opinions may vary in regard to personal taste or choice of style, and to the initiated, *i. e.*, the architect, the critic and the tremendous purchasing power, who are influenced by the judgment of these two groups. The acceptance or rejection of what is good or bad in art is clearly defined, and it is a verdict that no amount of advertising or publicity from commercial interests can reverse. It is equally definite that while questionable artistic production may be marketable, it will never be acceptable at any price to those who know good art, while the highest prices will always be paid for the real thing.

The time is now coming when the manufacturer will realize that not every professional decorator or modeler is an artist, and that scores of these earnest and well-meaning gentry, at present engaged in the production of decorative wares, are as much out of place as a gentleman from Pell Street would be on Bailey's Beach.

This again is a question of selection and organization. What is needed is not so much a new productive element in the factory, but a new directing and supervising element.

THE ARTISTIC NEEDS OF MODERN FAIENCE

By Conrad Dressler

In this paper I shall expand the views which I ventured to put before you at the meeting of the American Ceramic Society at Columbus in 1921. The conclusions I then arrived at were that as regards pottery:

The achievements of the past owed their beauty to the artist.

The excellent technique of the present is due to the efforts of the manufacturer and scientist;

The latter quality has now almost entirely superseded the former;

Yet the esthetic needs are eternal and cannot be denied.

The efforts of solitary artists are unavailing in a modern world of vast undertakings.

It is for the modern factory to re-introduce the artistic spirit.

Whether everyone agreed with me I cannot tell, but no one in any case among the manufacturers and potters present expressed any contrary views. Possibly the statement was too general to invite criticism. I propose in this paper, therefore, to make some more definite and more concrete suggestions and to offer a plan for introducing artistic quality into modern terra cotta.

Let us first understand that when we speak of artistic work, we mean work done by an artist. A photograph of a picture may be very clever and very good, but it is only a copy of the work of an artist. It is the picture itself that we must call artistic. If this is true, then we are faced with the problem that faience work which is to be artistic must be done by artists and cannot be merely a reproduction of work done by artists.

But you will say that this is quite impossible in a modern factory. You cannot have a couple of thousand artists at work molding, pressing, enameling and coloring terra cotta. The cost would be too great, and, moreover, where could you get such an army of artists? Yet such armies of artists existed in the olden time, when the Alhambra was built, when the Mosques of Brussa and Damascus were erected, when Rhodian tiles were so freely used all over Asia Minor. But even if these artists could be brought to life again, you will say they would not fit in with modern needs.

The time now given for doing the work is curtailed. The conditions of life are altered. Instead of men, girls and women are now employed in many of the processes. These know nothing of the uses which their work serves nor do they care. They are concerned only about wages. They can be made to be more or less careful by discipline, but more than that cannot be expected of them. In fact, there are few men in a large establishment whose taste can be trusted.

As a rule, the work is imposed upon the manufacturer by the architect. He selects the colors, the texture, the glazes from a series of examples or

"Prudence"—Enameled faience panel, 6 ft. x 3 ft. 4 in., by Conrad Dressler. Part of a decorative frieze in the Hall of the Law Society, London, England.

trials which are sent him, and as the shapes are all rigidly indicated in a blue print, the manufacturer's business, his whole duty and his only concern is to carry out the work as nearly as possible in accordance with the architect's instructions. If there is any artistry in the matter, it is entirely the architect's and if there is any credit for the job, it goes to him. He should share it in justice with the potter who made the trial pieces from which he selected the material he adopted. But even here, these trials may have been good and bad, and it was in the choice of the good or rather the suitable that the esthetic judgment had to be exercised.

But when all is said and done, and we look at the specimens of architectural terra cotta which adorn our large cities, it must be conceded that they are in no real sense artistic. They are not artistic in the sense of the buildings in Spain and in North Africa or Asia Minor which were done by the Arabs, and which were the first glazed or enameled terra cotta buildings to be put up in our era. Let us remember that this is an old art and that it had its origin in the Middle Ages. Our modern factories therefore have a pedigree and a very noble one, and we must see to it that we do not fall away from the high qualities of past achievement. Do not think that I propose that these old buildings should be copied. Let me tell you that such a thing is impossible, even if it were desirable. The modern architect can be trusted, moreover, as a man of culture and of taste not to fall into so grave an error as to attempt it.

But the architect, poor man, who wishes to do anything new and yet good, does not know which way to turn. He is not himself a potter, does not know the conditions under which pottery is best made, and on the other hand, he knows a great deal about stone work, so he designs a stone building and asks for pottery that shall look like stone. This is the principal reason for the failure of modern faience architecture. Stone is beautiful as stone, but pottery is poor stone, and yet pottery is magnificent, unsurpassable as pottery.

Look at the mosques in Turkey and tell me what stone building can compare with them. They gleam in the sun like jewels, their colors blend with the skies, with the dark cypresses, the green domes shimmer like jade and malachite. Can anything more fairy-like, more fantastically lovely be imagined?

I cannot believe that if the potters were able to place at the disposal of architects materials as enchanting as these, cultured as they are, they would not at once take them up enthusiastically.

Thus, the first part of my practical proposal is that you should not take your orders as potters from architects who can only give you drawings suitable for stone or granite buildings, but that you should show them specimens of such beautiful pottery-clad structures and so artistic that you will convert them to the use of pottery as a potter's material, and not as an

imitation of stone or granite. Now in order to achieve this, you need an artistic staff. Where will you get it or how will you train it?

Let me now explain what I consider as the first requisites, the natural and therefore the artistic requisites in architectural faience and terra cotta.

First, I do not think pottery should be constructional at all. It is not suitable for that purpose. It is true that bricks are constructional and are pottery, but when we come to tiling, to colored or plain enameled terra cotta, it is my strong belief that it should be treated merely as an outer decorative facing or skin to clothe the ribs of the building—what the French call *revètement*. As a matter of fact that is what it is now, for your terra cotta blocks are hollow, for the simple reason that that is the only way you can make them, dry them and fire them, and when they are placed in a building, if they are filled with concrete it is for strength only.

Why not accept the limitation you are under of making pottery thin and get the architects to agree to design their buildings with a facing of enameled terra cotta and no strong projections as in the case of stone? The potters have such a splendid means of giving variety to a façade in the way of string courses, sky lines, jambs, pilasters, etc., denied to the stone buildings, for have they not color? Whereas stone must have projections in order to show the different members by means of light and shade. Let them make much of this color, it is their legitimate heritage.

Another thing that distinguishes pottery and makes it different from stone, is that it is worked soft and should retain this appearance of plasticity when it is fired. The surfaces should be rounded and undulating, and pleasantly full and rich. Stone, on the other hand, is expected to be hard and flat with keen arrises.

These qualities *belong* to the materials, and they should not be *taken out* of them. Yet that is what is universally done.

But we now come to a matter requiring something more than just leaving the material to be seen with its native qualities. The clay has to be shaped variously to suit the different parts of the building. How beautifully that was done in the past! Think of the Frieze of Lions, or of the Archers at Susa; of the many fine examples of Greek or Roman terra cotta. I have in mind a noble country mansion in England, Sutton Place, built in the days of Henry VIII by Italian potters. It is a Tudor building with mullioned windows and the walls are decorated with crests and emblems of great variety and beauty. The Della Robbias again carried the decoration very far in their figure work, in medallions and framed niches. All these are very delightful examples of what can be done. But who is to do this sort of thing in these days? It needs artists. Now, what exactly are artists?

We see beautiful laces preserved in the museums, and we appreciate their artistry. Who made them? Just common peasant women in

France or in Ireland. They were the artists. They varied their stitches, seeking new effects and often attaining great quality of design. These arts have nearly died out, because machinery has killed them, but I have seen these women at their work still, and I know how freely they worked.

Just the power to ornament is natural to men and women, and I am convinced that properly led, you could easily build it up among your employees.

I have had that experience in England. I employed children out of a village and gave them tiles to decorate in enamels. I had naturally to restrict their freedom. They could only work within certain limits, but the quality of their work was such that these tiles gained a foremost place among the artistic productions of their kind..

It is, however, necessary to make those to whom you would give a certain freedom of control over their production, thoroughly understand the purpose you have in view. Let us now see if it would be possible within a modern factory to organize an artistic production on the lines I have endeavored to indicate.

Shall we assume that a commonplace, a plain brick dwelling house, such as we have so many ugly examples of in some streets of New York or Pittsburgh, is to be faced with terra cotta. The opportunities which we have to beautify it are two-fold. There are the plain surfaces. There are the openings: doors and windows. The plain surfaces can be cut up by means of colored string courses, and the top of the building can have a rather wide decorative band, like a crown or crest. The jambs of the windows and doors on the other hand can be quite decorative with fruit and flowers, or other cheerful devices, and if we wish to be ambitious, we can put round arches above them and fill the tympana with some emblems. On the other hand, the plain surfaces must be interesting and beautiful also, but as a contrast to the decorative parts.

I should, for the plain surface, use tiles of an oblong shape and give them slightly concave surfaces so that they may have a quality of fulness and richness. Now such tiles could be run out of a pug mill in a stream wire cut in lengths, and just faced by hand in an iron frame. In this way the needed precision of size and shape would be obtained, but the hand facing would determine that character of plasticity which will be so valuable. The man or woman who does this work will become an expert at getting the right qualities as soon as he or she knows and can appreciate what is needed, what in fact looks nice, so that he or she should have this appreciation. I should provide, outside the factory in the open air, if possible in a pretty court yard planted with shrubs and flower beds, some blank walls upon which the finished work can be temporarily set for the purpose of enabling the work people to see what it is they have done, what it looks like when up, and whether or not it looks well.

This plain tile when fired will have to be enameled. Here again, to merely dip it into a plain enamel or to spray it will make it look mechanical. I would have the plain enamel dipping followed by the application with a coarse brush of a very liquid toned glaze. The hand work will cause a difference in the toning and will give a natural variety which will prevent even the plain part from being monotonous. It will look white, but still a little green, gray or rosy in places, just because it will be done by hand. Now the only artistry in this is the uncertainty of the human hand. But there is such a thing as negligence and as excess of contrast, and the girls who do this work will also appreciate this when they see their work up in the little court yard.

We now come to decorated parts. Let us take a string course, and let us suppose that we have decided to use a molding with a series of conventional roses at intervals and with some binding knot between. The field of design is so rich that it is endless, and I have named something very simple.

Let us suppose that these ornaments have to be fixed inside a *cavette* in the molding. The molding would, of course, be run through a mouth piece and cut in lengths. It would then be brought to the bench of the decorators. I assume that girls again, under the direction of an artist, would deal with it. Now these girls would be supplied with molds in which they would press the ornament and then fix it by means of slip to the face of the molding. They would have to be very careful to place the flower where it would belong and the knot ornament between and to press them down with their fingers. They would have a wooden tool in their hands with which they would make good any deficiency, and give spirit to the design, joining the two elements. There is nothing difficult about this, but it would exercise their artistic faculties, and when eventually they saw their work in position, they would be able to appreciate which was well done and which was not. Such work is nothing like so difficult as trimming a hat or making a blouse, and what young girl is not able to do that?

I will not go any further in the matter of slip decoration, because it is all along the same lines. The moldings can be more or less elaborate. The patterns can be as elaborate as you please, but by treating them this way, you bring freedom of human touch into play, and this is the artistic quality that tells.

Coming now to colors, let me say this. There is nothing more dangerous in such work than bad use of colors. If I were a potter, I should fix upon a particular tone for my plain surface, and I should make this so beautiful that I could do no better. Then I should stick to it and refuse to do anything else. And as regards the decorated borders, I should use four or five colors which suit my materials and which go well together, and then I should never vary them.

The variety would be in the motives. There you have the whole world before you. You have all the arts of Europe and Asia and nature itself to inspire you.

For the purpose of working out suitable decorative motives, you will need a few artists who will model them, and from their models the plaster mold can be taken, out of which the girls will squeeze them.

The latter can be taught also to model a little, so that they can do their work more intelligently and the more talented ones may in time become the modelers. With regard to central figure work for the tympana, or for panels, you may have to bring in an outside artist. But he must work in the factory with the others, and also see his work in the little court yard, otherwise he will not be able to judge of the effect; for a perfect harmony must exist between every part of the work, and therefore among the workers.

Does this sound like a dream? Certainly it has never yet been done here, but in a small way I have had that experience in my pottery in Birkenhead and later in Marlow, and I do not see why it should not be done in this country of progress and enlightenment. I venture to say that whoever undertakes it will be astonished at the eagerness with which the workers will take up the idea, and the spirit of good-will and enthusiasm which will animate them. The reason for this is that they will be treated once more like real people, not simply adjuncts to machines. Their sense of beauty will be awakened and cultivated, and as they give it out, the people who see the results will enjoy them as much as they themselves, for Art is a real bond between man and man, and we need that bond more in these days than every before.

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THE PROBLEM OF THE TURQUOISE ALKALINE GLAZE

By Myrtle Merritt French

ABSTRACT

The method of producing a turquoise blue glaze which would be insoluble on the finished piece is described. This glaze is also designated to so cover the pottery as to make it impervious to water. The method requires a great deal of attention and it is doubtful if the result will ever be a great commercial success, but the beauty of the glaze makes it very satisfactory.

The object of this study was to produce a turquoise blue glaze which would be insoluble on the finished piece and would so cover the pottery as to make it impervious to water.

The experiments were fired in a muffle furnace to cones 09–06 for both clay and glaze. The following formula was used at first and the glaze was colored by copper oxide in amounts varying from 15 to 27 parts in the batch of glaze.

Na_2O	0.3		
CaO	.3	B_2O_3 .1	SiO_2 1.8
K_2O	.3		
MgO	.1		

The ingredients were all fritted and ground for several hours. The result was a mass extremely difficult to manipulate, but the concern being at the moment chiefly with the color and fitting of the glaze, that difficulty was temporarily ignored.

The relation of glaze to body was approached by way of the clay. A first mixture was made consisting of:

Flint	53.8
J. P. No. 9 Ball Clay	16.0
Whiting	.2
	70.0

and upon this a triangular series was built in the following combination:

A.	Clay	70
	Glaze frit	30
B.	Clay	70
	Sharp sand	30
C.	Clay	70
	Whiting	30

Of this series number 9 seemed the best. The composition of this was:

Flint	53.8
J. P. No. 9 Ball Clay	16.0
Whiting	12.0
Sharp sand	6.0
Frit	12.0

All the bodies were too short to work well and the glaze crazed upon all of them. After many efforts to increase the plasticity and stop crazing, the idea of using frit in the clay was abandoned because the bodies were so difficult and expensive to prepare that the result would be impracticable.

Next a series of bodies was based upon the No. 9 mixture but leaving out the frit. The ball clay was increased at the expense of the whiting and either kaolin or feldspar was added. In every case the glaze crazed. With a view to increase the silica through a plastic material and to produce a whiter body, Cornwall stone was tried by the following combination:

	Cornwall stone	86
9J	Sharp sand	6
	Whiting	8

This body was more plastic, much whiter. It vitrified at about cone 1, but still the glaze crazed. Monmouth clay was then tried in proportions varying from 45% to 81%, plus flint 5% to 44%, keeping the sand at 6% and varying whiting to complete the 100%. These bodies turned the glaze green though they were more plastic—especially those with less free flint. The glaze continued to craze.

Through a combination of Monmouth clay and Cornwall stone a body was produced as follows:

9S	Cornwall stone	56
	Monmouth clay	25
	Whiting	8
	Sand	6
	Flint	44

This body was plastic and there was less crazing though the color still lacked the pure blue of the Persian and Egyptian. By means of small changes 9S was altered until the crazing and the poor color were overcome but the plasticity problem was still only partially solved. Notwithstanding this, however, bowls with a 45 degree flare and vases eight or ten inches high were successfully built. The changes involved a constant increase in the flint, certain variations in the proportion of clays and the introduction of kryolith.

The following schedule covers the range of bodies tried as modifications of 9S. All of them worked well so that there is but little choice between them.

	1	2	3	4	5	6	7	8	9
Cornwall stone	17	..	..	..	17	..	..	..	..
Tenn. Ball No. 9	15	18	18	14	17	13	18	18	14
Ga. kaolin	..	..	..	..	..	19	..	..	9
Eureka spar	..	12	10	19	..	..	12	14	8
Kryolith	8	8	8	8	6	6	6	6	7
Flint	60	62	64	59	60	62	62	62	60
Whiting	..	..	..	..	..	..	2	..	2

From these experiments, the following conclusions are drawn. Free flint must be from 60% to 64%. The addition of 4% to 8% of kryolith will lower the firing point of the body. The sum of the ball clay (J. P. No. 9), Georgia clay and feldspar may vary from 28% to 34%. One, two, or all of these may be used in the same body. If Cornwall stone is chosen, the body has more the appearance of a porcelain. A little whiting may be added if desired.

While evolving the clays as stated above, the glaze problem was not forgotten. The glaze given at the beginning was tested on every clay, but each time it crazed.

Every effort to use Al_2O_3 or B_2O_3 resulted in a greening of the glaze. Finally the R_2O_3 column was omitted entirely. PbO, BaO and MgO seemed to turn the glaze toward green. No perceptible difference was noticed in an interchange of K_2O and Na_2O. After numerous experiments it was found that 2.8 SiO_2 was the best content since a glaze containing that amount fitted practically every body made according to previous directions. A glaze with 3 SiO_2 crazed on the outside of a bowl when one having 2.9 SiO_2 did not craze on the inside of the same bowl. The two were handled simultaneously in exactly the same way except the glaze of the latter was thicker if anything. No attempt is made to explain this action.

Since PbO, BaO and MgO were to be discarded, only Na_2O, K_2O and CaO were left. CaO .3 was as high as the desired firing point allowed, leaving .7 for the other two. A glaze of this formula was therefore chosen:

Na_2O	0.6	}
K_2O	.1	} SiO_2
CaO	.3	} 2.8

of which the batch works out as:

Soda ash	64
Niter	20
Whiting	30
Flint	168

Na_2O .7 and CaO .3 was just as satisfactory. As it was not possible to frit all the flint, 100 grams of flint were included in the frit and 68 grams added raw. The raw flint ground in the ball mill with the frit kept it from sticking to the pebbles in a stone-like mass as did the glaze given early in this article. The resulting mass was difficult to manage unless mucilage was added; but by so doing, a skilled person could manipulate it with little trouble. It could even be sprayed. The glaze seemed entirely insoluble after being fired and was sufficiently viscous to stay in place—a statement which could not be made concerning the first glaze. Attempts were made to fit a glaze, engobe, and body clay, but that seemed too complicated a problem until a few further facts were established as a working basis.

From results obtained, however, there seems to be no doubt that the color effect can be obtained by that process.

It is very doubtful whether this type of pottery will ever be a success commercially, because each piece must be given much attention. However, the joy of the color in the finished piece is full recompense for the necessary care. Not long ago, it was asked if the fact had been noted that the color produced by copper in an alkaline glaze was so much more beautiful than color in any other glaze. It is the glory of the achievement in this very color that had made possible the enthusiasm and perseverance required to overcome the many difficulties and to devote the necessary time to the problem.

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THE POLARIZING MICROSCOPE AS AN AID IN FELDSPAR STANDARDIZATION

By Howard C. Arnold

A colloquium was recently held on methods for the standardization of feldspar. Examination with the petrographic microscope was not, however, included among the suggestions offered, and it appears to the writer that the ceramic industry is losing valuable information by failing to utilize an instrument which can be of the greatest assistance in the evaluation of feldspar.

The practical applications of the petrographic microscope were pointed out by Dr. W. J. McCaughey in a paper before this Society in 1913.[1] Although the theory involved in the use of the petrographic microscope is not familiar to the average technical student, still the actual tests and methods of differentiation are of the greatest simplicity and can be mastered by any one who knows the elementary laws of light.

For the identification of crystalline minerals nine different determinations may be used; namely,

1. Indices of refraction, or refringence.
2. Classification as isotropic, uniaxial or biaxial.
3. Birefringence.
4. Sign.
5. Elongation (including sign, direction and extinction angle).
6. Color.
7. Pleochroism.
8. Dispersion.
9. Twinning habits.

Any given mineral, depending upon its crystallization form may have one or all of the above characteristics. For a brief, concise statement of the principles underlying the determination of these properties the reader is referred to articles by Dr. W. J. McCaughey.[2] The sole purpose of this paper is to emphasize the importance of using the petrographic microscope in studying feldspars and all primary silicate minerals, or silicates separated from cooling magma.

A perusal of the papers and discussions presented to the colloquium shows important problems arising from the following factors:

1. Accessory minerals occurring with feldspars which are detrimental to its use in ceramic work. The more important of these are
   (*a*) Micas (muscovite and biotite)
   (*b*) Garnets
   (*c*) Tourmaline
   (*d*) Hornblende
2. Free silica or quartz.
3. Shapes and sizes of the grains produced by different methods of grinding.
4. Nature of dark impurities other than minerals mentioned above occurring in powdered feldspar.
5. Variations in quality in different shipments of feldspar.

[1] *Trans. Amer. Ceram. Soc.*, **15,** 381 (1913).

[2] *Ibid.*, **15,** 322 and 381 (1913).

In many cases the producers and consumers are handicapped by a lack of information on the above subjects, which makes it difficult for them to know in what direction to proceed for correction. The petrographic microscope can be considered an instrument placed at their disposal to assist in securing this information.

In order to illustrate specific applications of the microscope let us take up the above problems.

1. **Accessory Minerals in Feldspar.**—The two micas, muscovite and biotite, and sometimes the alteration product sericite, are easily identified in any mixture of finely ground minerals. By observing several slides, and actually counting the number of grains present one can tell the percentage of mica grains, either muscovite or biotite, or both, in any given sample of feldspar. This is of particular value to the consumer who receives his feldspar fully ground and cannot tell with the naked eye how large a percentage is present. The grains are distinguished from feldspar grains by (1) indices of refraction, (2) birefringence, (3) cleavage, (4) elongation, (5) color, and (6) in some cases pleochroism. Biotite is differentiated from muscovite by color, optic angle, and pleochroism. When biotite is altered its products are usually iron stained, whereas muscovite leaves colorless minerals.

By taking a small sample of a new feldspar and observing it under the microscope, a consumer can tell, even before purchasing, the amount and nature of the mica in the feldspar and whether or not it is going to give him trouble.

What has been said above for micas applies also to garnet, tourmaline and hornblende. Garnets are distinguished by being in the isotropic division, by their color, and by their index of refraction. The fact that garnets crystallize in the isometric system, and are, therefore, isotropic, distinguishes them immediately from all other minerals commonly found associated with the feldspars. Color and indices of refraction can be used to determine the kind of garnet. As with the micas so also with garnets, the iron-bearing variety being the one which causes the most trouble in the finished product.

Tourmaline is identified easily under the microscope. The one property of pleochroism alone is sufficient to identify it. This test is further supplemented by color, refringence and birefringence tests (although these latter are dependent somewhat on the composition) and also by its elongated crystal form. In any ground mixture of feldspar the amount of tourmaline present can thus be easily determined.

Hornblende is a dark, iron-bearing mineral; the percentage of iron varies. With increase in iron there is a corresponding darkening in color. The index of refraction, or refringence and birefringence are characteristic

of the mineral, as also the angle of cleavage, extinction angle, pleochroism and color. These properties make it a mineral easy to identify.

2. The Determination of Free Silica, or Quartz.—This problem has never been satisfactorily solved by chemical methods. The accepted chemical procedure as outlined by Mr. Ladoo[1] at its best offers a most unsatisfactory solution. With the petrographic microscope it becomes simply a matter of sorting out the actual quartz particles from the feldspar, an operation as simple as sorting peaches from pears. By using the proper oil, with an index of refraction between that of quartz and feldspar, and by setting the microscope to observe the Becke line reaction one merely counts the quartz particles in a total field. By observing several fields (and they will not vary to any great extent) the content of free quartz can be determined. This is a very important factor to consider in purchasing feldspar; and it can be determined in a satisfactory manner only by the use of a petrographic microscope.

3. Study of Grain Shapes and Sizes as They Are Produced from Different Grinding Methods.—Mr. Landers[2] has stated in his paper that different methods of grinding influence somewhat the shape of the feldspar grains produced, and in turn this difference in shape is the cause of differences in rate of settling. Of course the application of the microscope to this specific problem is obvious. However, it goes further and opens up a complete line of research upon the effect of different grinding methods upon the shape and size of particles; their influence upon the proportion of coarse and fine materials; the progress of the grinding operation with time and the effect of introducing variations in the process. Mr. Landers states that wet-ground feldspar will settle five times as fast as dry-ground, and yet both give the same screen analysis. What could be more natural than to actually examine these grains with the microscope with a view to find an explanation for such an anomalous behavior? In determining fineness of grain a cross-sectional eyepiece could be used on which actual dimensions are read. Or if one wished to study carefully the proportions of different grain sizes, the whole field could be plotted for a permanent record.

4. Nature of Black Specks in Ground Feldspar.—Besides the dark colored minerals, which can be determined as outlined above, other black specks in feldspar can be identified. Free iron, accumulated through the grinding, elevating, and conveying machinery, as well as coal, cinders and dust, which may accumulate can be absolutely identified. With such information available one can find definitely the source of the black specks

[1] R. B. Ladoo, "Conditions in the Feldspar Industry," *Bull. Amer. Ceram. Soc.*, **1**, 7 [Feb. 20], (1922); "Colloquium on Feldspar," *ibid.*, **1** [7] 78–101 (1922); *ibid.*, **1** [8] 133–46 (1922); *ibid.*, **1**, 269–95 (1922).

[2] "Colloquium on Feldspar," *loc. cit.*, **1** [11] 271 (1922).

and take all possible steps toward their elimination. Needless to say, such information is invaluable.

5. Constancy of Quality in Shipments.—C. N. Franzheim[1] has drawn attention to the difficulty of getting uniform shipments of feldspar from year to year. However, the writer is inclined to agree with Mr. Landers in his reply to Mr. Franzheim when he says that none of the rock products entering into the ceramic industry occur in such a pure state and in such large bodies that they have to be considered only from the point of view of their preparation. In other words feldspar is not a prepared product, and as such its purity will of necessity be limited to the available deposits. If it were a soluble product, and could be dissolved, separated from its impurities, and precipitated, then a commercially pure product could be obtained. But where the nature of the material prevents such a process we shall have to resort to physical means, and of course in these we are distinctly limited. Gravity separations will undoubtedly assist in securing a purer feldspar but this method is limited because the impurites present do not vary enough from feldspar to make the method of general application. Any deposit of feldspar is more or less a mixture of minerals. Some are purer than others, but all contain some other minerals. Even our best potash-feldspars turn out to be microcline instead of orthoclase. Although these two minerals when pure have the same composition, still they have physical properties somewhat different, and after weathering their compositions will not be the same. Additional information is thus obtained on the character of the original feldspar deposit by knowing whether the actual mineral is orthoclase or microcline.

Besides being associated with each other the two potash feldspars are intimately mixed with soda feldspar. In fact the minerals orthoclase, or microcline, and albite crystallize in an actual intergrowth called perthite. This intergrowth may or may not be visible to the naked eye. From albite to anorthite, the lime feldspar, we have a complete isomorphous series, albite, oligoclase, andesine, labradorite and anorthite being the principal members. These feldspars all have individual physical properties, and of course have a definite effect on the action of the bulk of feldspar. No wonder Mr. Franzheim points out the difficulty of getting his various shipments of feldspar to act uniformly. If he had an intimate knowledge of the exact ingredients which made up his feldspar shipment he could anticipate its action before he used it. If necessary he could modify the remaining ingredients in his body and correct for the feldspar impurities. If his second shipment ran higher in quartz than the first, he could decrease flint and increase feldspar accordingly. If his easily fusible soda feldspar content increased at the expense of the potash feldspar, he could decrease his total feldspar addition and increase refractories. The same reasoning

[1] "Colloquium on Feldspar," *loc. cit.*, **1** [11] 292 (1922).

applies to the presence of feldspars other than potash or of soda-feldspar in the raw product. There would be required, of course, a large amount of empirical information before the method reached an application as specific as that outlined above, but the polarizing microscope is the tool by which this information can be secured.

The writer makes no claim to originality in the above discussion. He has made free use of the standard authorities on mineralogy and petrography. His idea is to point out the value of the petrographic microscope, the practical results which can be obtained by its use, and if possible, to emphasize the loss the industry is suffering by not adopting it for working out definite specifications for feldspars.

ARTHUR D. LITTLE, INC.
CAMBRIDGE, MASSACHUSETTS
November 21, 1922

FELDSPAR FOR GLASSMAKERS

BY F. C. FLINT

Introduction

Feldspar for a long time has been used extensively only by manufacturers of clay wares, such as porcelain, sanitary ware and enamels. Recently its use has grown into the glass industry to such an extent that it is developing into a considerable factor in the feldspar quarryman's business. As the feldspar was formerly ground according to potters' standards entirely, it was not as good for glassmakers. This was chiefly on account of its fineness. The cost of production also was higher because of the length of time required for grinding. It is hoped that producers of feldspar will be able to grind a coarser grade of material for glassmakers, which should enable them to do it more economically and at the same time assist them in keeping away from the liability of introduced contamination, for the less the material is handled the less the danger of introduced iron.

Use of Feldspar

The feldspar is added to the glass for its alumina content. The potash and soda is valuable, but not essential as it can be added economically in other forms. The use of alumina is an old custom, accidently at first, but now comparatively common. It is not an easy thing to put in the batch without proper control, part of which evolves on the producer of the raw material. The chief difficulty is the variation in iron content and in the important constituents. If a glass formula is made up it should be kept constant.

If the ingredients such as the alumina or alkali vary, it is a serious matter for these variations tend to produce cords in the glass, one of

the most difficult troubles to locate and correct. Changes in the source of any one material may also cause this as well as variation in the composition of material from some one source. When these variations occur, the trouble is sometimes blamed on the batch formula or mixing, when a series of analyses would show the true cause of the difficulty. And every one is not in a position to make a complete analysis on every car of material that comes in.

Feldspar is not the only thing that is used for its alumina content, as occasionally alumina oxide or hydrate is used; also cryolite, clay, kyanite, obsidian, granite, mica and lepidolite. Their value is comparative, according to the content of the material and the form in which it is found.

Grinding

Ceramic ware usually demands a feldspar of great fineness, 100-mesh or greater. On the other hand, for the glassmaker there is a limit to the fineness which is desirable. When mixed with batch materials, any material which is over 80-mesh in fineness has a tendency to ball up, which means that ultimately the effective size of the particles in the batch is very much coarser than a very coarse grind. It is preferable to have a size of approximately 40-mesh. From a practical standpoint, if the feldspar were ground to all pass a 40-mesh sieve, there would be sufficient particles of greater fineness to give a good average grade, and yet the feldspar would run much more freely than if it were 80-mesh or finer. This not only facilitates the mixing of the feldpsar in the batch, but it cuts down the dustiness and the subsequent loss in handling. This should permit feldspar grinders to use a much simpler installation than they now can use, or should permit them to get a greater tonnage from their present equipment. It would eliminate the long, slow grinding in the ball mill to obtain the small percentage through a very fine mesh. A simple installation would be the use of a manganese jaw crusher feeding a continuous chaser mill or ball mill, from which the feldspar would pass though a 40-mesh screen, the oversize being returned to the mill. It would be very poor policy to sieve out the extremely fine material for one use and save the coarse for the glassmakers, because any free silica that may be present is hard enough to resist grinding and would greatly increase the total silica content in the coarse material and correspondingly decrease the alumina and potash content. A magnetic pulley would greatly reduce the liability of introduction of tramp metallic iron from the mill.

Feldspar Specifications

Iron.—Feldspar, which was used by potters, was chiefly inspected for fineness of grind and for small specks of color due to iron or iron bearing

minerals. Sometimes the amount of iron in a feldspar was very low, but if it was in a form which gave these dark specks it was impossible to use it. On the other hand, iron which was uniformly combined with the feldspar, did very little damage until it was so very high that it produced a yellowish color, provided always, that it did not show up in the form of specks.

The glassmaker is not interested in the form in which the iron may occur, for in the glass batch this iron melts and diffuses throughout the glass, giving the characteristic greenish cast. A relatively low quantity of iron oxide is desirable in an average flint bottle glass, so that it may be successfully decolorized. This iron may be introduced in a number of forms. It may occur as some of the high iron bearing minerals, such as pyrite, limonite, ilmanite, magnetite, garnet, hornblende, mica, etc., or it may be introduced from the machinery of the mill, or in handling. A quarry which contains iron in any of the mineral forms must be well sorted to remove these minerals. There are various methods of doing this, but practically all of them depend upon the ultimate care and skill of the quarryman. It is a fortunate quarry indeed that does not have to select extremely carefully. From the glassmaker's standpoint, these minerals, particularly garnet, ilmanite, tourmaline and mica are only considered from the iron they introduce, not on account of specks.

The iron which is introduced in the mill varies with the various types of mills and the care with which it is kept up. Conveyors can introduce iron as well as the grinding machinery and even cars during transit can introduce an appreciable amount. A magnetic pulley should be used to remove the metallic iron which is introduced in the operation of sorting, grinding and moving.

A very important feature in the production of feldspar is reliable information as to the content of iron oxide.

It should be remembered that the analysis is given, not as metallic iron, but as iron oxide, for it is in this form that most of the iron occurs naturally in rocks. The analysis should be given for iron oxide alone, not iron and alumina, and should extend to 0.01%. If the analysis is made by a reliable chemist, or commercial laboratory, particularly one who is accustomed to analyzing silicates, there is little danger that the analysis will be far from correct. This is particularly true of commercial laboratories where duplicate analyses are run before the report is made.

Alumina.—The alumina content for which the feldspar is generally used, should above all things, be constant. It need not necessarily be high if the price is adjusted accordingly, but it should not vary from one lot to another. Inasmuch as this is one of the more difficult things to analyze for, and is slow work, it is not often checked up.

Silica.—Silica may be considered only as a diluting material in the glass trade. It makes no difference if it is combined or free, it can be bought cheaper in the form of sand and often more pure. It has no deleterious effect on the glass other than that a variable increase, particularly if it is not expected, changes the properties of the glass.

Alkalies.—The most important consideration in the use of feldspar is that the total alkali be constant and be high enough to warrant its use. If it is low it cuts down the value of the feldspar, for soda ash must be added, and if it varies it causes the glass to become harder or softer as the case may be, another cause for cords, seed, etc.

Other impurities, such as lime, magnesium, titanium, etc., generally occur in too small quantities to be worth consideration. If they are present to any appreciable extent, it should be known so that the batch may be corrected to suit. Here too, unwarranted variation is harmful.

The greatest difficulty in obtaining a true analysis of such material is in the sampling. Oftentimes the analyst does not have the opportunity to do this and the man at the quarry does not have an adequate conception of the importance of this job. In most any quarry one can pick up perfectly pure, clean samples and he can also find rock which no quarryman would use. Nature does not produce chemically pure materials very frequently. Therefore, it is of very little use from a commercial standpoint, to select samples for analysis. A true representative of the quality of feldspar from any quarry can only be obtained by taking a frequent number of small samples during any given operation. If these are taken after the first crushing, and it is best not to take them before, a large pile of samples should be collected on a clean floor, turned over and over with the large lumps broken, and the pile reduced by quartering. Then, when the sample is made fairly small, the material should be ground in a separate, clean hand mill and further mixed and quartered until a small sample of sufficient size can be taken to the laboratory. In a quarry that is operating, the feldspar which is going out to the customer is most pertinent, so samples should be taken at regular and frequent intervals while the car is being loaded. This should then be thoroughly mixed and quartered down until a half pint sample is obtained and this should be sent to the analyst, who will then further quarter and sample until he gets a representative small amount from the sample which has been sent him. Only by going to this great care can reliable analyses be made. The customary habit of reaching in a car door and filling a bag or bottle from some one spot on the surface has caused more unreliable analyses than any one practice of sampling.

HAZEL-ATLAS GLASS CO.
WASHINGTON, PA.

THE MEANING AND MICROSCOPIC MEASUREMENT OF AVERAGE PARTICLE SIZE[1]

By G. St. J. Perrott[2] and S. P. Kinney[3]

The influence of particle size on the properties of pigments, fillers, and ceramic materials is well recognized. The meaning of the term particle size or average particle size is less clearly recognized. This paper endeavors to present an analysis of the term and to set forth a method of calculating average particle size which gives a value capable of physical interpretation. The results of microscopic measurements of samples of pulverized coal together with calculations of the average particle size are then given.

The work outlined in this paper was done in connection with the Trent Process for cleaning finely ground coal.[4] In this work it appeared desirable to investigate the relation between ash removal and fineness of pulverization or in other words to show quantitatively to what degree of fineness it was necessary to grind different coals in order to secure optimum separation of mineral matter from combustible matter. It was necessary (1) to define the meaning of average particle size as applied to our purposes and (2) to develop a rapid method for determining this value.

Various methods of computing the average particle size of a finely divided material have been employed by other workers. These have been discussed at length by the ceramics investigators. These workers have employed elutriation methods to separate that part of the material passing a 200- or 300-mesh screen into fractions containing a range of decreasing sizes. They have been interested in determining the "average diameters" and relative "surface factors" of different clays. The surface factor[5] has been shown to be proportional to the reciprocal of the average particle diameter or in other words to $\sum \frac{y}{d}$, where y is the percentage weight of the elutriation fraction of average particle diameter, d.

If it were possible, it would be desirable in elutriation procedure to make a sufficient number of fractions so that each contained particles of identical size. As it is impracticable to make so large a number of fractions and impossible in any event to get so clean a separation, each fraction contains a range of sizes. It is necessary to calculate the average particle size of this fraction before calculation of the average particle size of the total sample can be made.

[1] Published by permission of the Director, U. S. Bureau of Mines. Rec'd. Nov. 18, 1922.

[2] Associate Physical Chemist, Pittsburgh Station, Bureau of Mines.

[3] Asst. Metallurgical Chemist, Pittsburgh Station, Bureau of Mines.

[4] Perrott, G. St. J., and Kinney, S. P., "The Use of Oil in Cleaning Coal," *Chem. & Met. Eng.*, **25** [5], 182–8 (1921).

[5] See Ross C. Purdy, Ill. Geological Survey, *Bull.* **9**, 150–154 (1908).

Elutriation was too tedious a procedure for our work and seemed to advance us but little, due to the fact that the average particle size of the separate fractions must be determined microscopically. A method of estimating average particle size by a microscopic count of the gross sample was accordingly developed. The amount of time save by elimination of the elutriation procedure is enormous.

The "Diameter" or "Size" of a Particle

The particles of a pulverulent material are neither spheres nor cubes. Frequently one dimension is considerably less than the other two. Ordinary microscopic measurement shows but two dimensions, although the third dimension or thickness may be measured if necessary. Determination of a single dimension, "diameter," or "label" by which we shall designate a particle is difficult and an approximation at best.

If the particle is assumed to be rectangular and its dimensions are designated by l, b, and t, the average dimension of the particle might be calculated in one of several ways:

(1) $\frac{l+b}{2}$ (2) $\frac{l+b+t}{3}$ (3) $\sqrt{l \times b}$ (4) $\sqrt{\frac{2lb+2bt+2lt}{6}}$

(5) $\frac{3lbt}{lb+lt+bt}$ (6) $\sqrt[3]{l \times b \times t}$

(1) and (2) are statistical averages, (3) is the side of a square of area equal to the face examined, (4) is the side of a cube of surface equal to that of the particle, (6) is the side of a cube of volume equal to that of the particle.

Formula (5) is the harmonic mean of the dimensions and is related to the specific surface or surface per unit weight of the material.[1] The relation between the total surface S in unit weight of material of density ρ, consisting of spherical or cubical particles of diameter μ can be shown by arithmetic to be as follows:

$$\rho S \mu = 6 \qquad \text{I}$$

Where the particles are rectangular parallelopipeds, μ can be shown to be the harmonic mean of the three dimensions.[2]

[1] Green, Henry, "A Photomicrographic Method for the Determination of Particle Size of Paint and Rubber Pigments," *Jour. Franklin Inst.*, **192**, 638 (1921).

[2] $\mu = \frac{6}{S\rho}$, where S is surface per unit weight I

$S = N \times s$, where N is number of particles in unit weight and s the surface of each particle

$= \frac{l}{\rho(lbt)} \times 2(lb + lt + bt)$

Substituting in I, $\mu = \frac{3lbt}{lb+lt+bt}$ (5)

(5) seems the most logical value to be used in work with pigments, ceramic materials, and fillers where a dimension related to the total surface per unit weight or volume is desired.

Since the labor of microscopic analysis cannot be increased indefinitely, it has been the custom, sufficiently accurate for most purposes, to measure the dimensions of the particles in one direction across the microscopic field giving in effect a summation of $\frac{l+b+t}{3}$.[1] In our work, as described later, the average dimension of the individual particles has been obtained by a visual carrying out of the operation indicated in (3). This value was employed because of the need for our purposes of a rapid method and not because we believed the value to be theoretically correct.

The Average Diameter or Average Particle Size

After we have obtained, with considerable effort, the relative numbers of particles of various diameters we are by no means at the end of our labors. We now desire a single value, an average particle size, which will express the degree of fineness of our material.

The value for this average particle which is at first sight most obvious is the statistical mean or $\frac{\Sigma nd}{\Sigma n}$ where n is the number of particles of diameter, d. This procedure often gives undue weight to the smaller particles. A given sample may contain a small weight per cent of ultramicroscopic particles but such a large numerical percentage that the average diameter so calculated would be of ultramicroscopic magnitude. Statistically speaking the average particle *is* ultramicroscopic just as, numerically speaking, the average particle in a ton of run-of-mine coal is ultramicroscopic. Practically speaking, the value is often of little significance.

Workers with pigments and ceramic materials are interested in the tinting strength, covering power, or obscuring power of a pigment, and in the total surface exposed by the particles of a material to be used for ceramic purposes or as a filler. These properties are dependent not alone on the number of particles of a given size but on their surface. One 10-micron particle has a surface equal to that of 100 1-micron particles or of 10,000 0.1-micron particles.

The term *average* diameter or *average* particle size can be strictly applied only to the value calculated as indicated by the expression $\frac{\Sigma nd}{\Sigma n}$. This value, however, merely indicates that size of particle which is present in greatest number. It is desirable to express the degree of fineness of a pulverulent material by some value which is directly related to its physical

[1] True for small particles whose dimensions are fairly symmetrical.

properties. For example, the particle size of a clay to be used as a filler should be expressed by a figure indicating the total surface in unit volume or weight, and the particle size of a finely ground coal should be expressed by a value indicating the extent of separation of impurities from valuable coal. As will be shown later, these values may differ considerably from the numerical mean diameter.

Green[1] in a recent article on determination of particle size of paint and rubber pigments, states as follows:

> The character and behavior of fine pigments depends to a large extent on the magnitude of their specific surface.....it is convenient to take for the diameter of a particle that dimension which bears to specific surface the simple relationship shown in equation (1) ($\rho S\mu = 6$). If it is stated that the particle size of a sample of zinc oxide is 0.52μ, then it is meant that this is the diameter of the average particle. Such a fact may be used to determine specific surface but aside from this it gives but a poor visualization of the texture of the material, for it neither discloses whether the oxide is composed entirely of particles 0.52μ in diameter nor whether it is a mixture ranging from ultramicroscopic particles to grains as coarse as sand and average 0.52μ.

Green recognizes the importance of specific surface as a factor in determining the character and behavior of pigments but neglects it entirely in calculating his average particle sizes. He determines his averages on the basis of the number of particles of various sizes and takes no account of relative surface or weight represented by particles of various sizes. The error introduced in his averages is not large, due to the high uniformity of the pigments investigated. Consider, however, the pigment "ranging from ultramicroscopic particles to grains as coarse as sand." The specific surface of such a pigment would be considerably less than the specific surface indicated by the average diameter, 0.52μ, because the relative surfaces of the particles per unit weight of material have been neglected in calculation of this value.

The magnitude of the value for "average particle size" depends upon the weight given in calculation to the factors (1) number and (2) length, (3) surface and (4) volume of the particles of the several sizes. Thus the term "average particle size" is capable of various mathematical interpretations, many of which have little physical significance.

The influence of the method of calculation on the magnitude of the value for average particle size is apparent from the following calculations based on data from microscopic examination of a sample of pulverized coal.

Strictly speaking, equation (1), Table I*b* is the only one of the four equations which gives an average diameter. The other equations give values which for certain purposes may be called *effective* average diameters. To avoid multiplication of adjectives, the term average diameter has been retained as referring to all four values but is in each case carefully defined.

[1] Henry Green, *ibid.*

TABLE Ia

MICROSCOPIC ANALYSIS OF PULVERIZED COAL

Diameter, microns	60	50	40	30	20	10	5	2
Relative number or frequency	87	100	156	660	1750	6200	25600	155000
Percentage of total								
1 Number: $\frac{n}{\Sigma n}$	0.05	0.05	0.1	0.3	0.9	3.3	13.5	81.8
2 Length: $\frac{nd}{\Sigma nd}$	0.9	0.9	1.1	3.5	6.1	10.9	22.4	54.3
3 Surface: $\frac{nd^2}{\Sigma nd^2}$	7.8	6.3	6.3	14.9	17.6	15.5	16.1	15.6
4 Volume: $\frac{nd^3}{\Sigma nd^3}$	22.5	14.9	11.9	21.3	16.7	7.4	3.8	1.5

TABLE Ib

CALCULATION OF AVERAGE PARTICLE SIZE

General Equation: $d_{av.} = \frac{\Sigma yd}{100}$ where y is the percentage of total (1) number, (2) length, (3) surface, (4) volume represented by particles of diameter, d.

Average particle size calculated according to percentage of total:

1. Number $d_{av.} = \frac{\Sigma yd}{100} = \sum\left(\frac{n}{\Sigma n} \cdot d\right) = \frac{\Sigma nd}{\Sigma n} = 3.0\mu$

2. Length $d_{av.} = \frac{\Sigma yd}{100} = \sum\left(\frac{nd}{\Sigma nd} \cdot d\right) = \frac{\Sigma nd^2}{\Sigma nd} = 7.0\mu$

3. Surface $d_{av.} = \frac{\Sigma yd}{100} = \sum\left(\frac{nd^2}{\Sigma nd^2} \cdot d\right) = \frac{\Sigma nd^3}{\Sigma nd^2} = 21.0\mu$

4. Volume $d_{av.} = \frac{\Sigma yd}{100} = \sum\left(\frac{nd^3}{\Sigma nd^3} \cdot d\right) = \frac{\Sigma nd^4}{\Sigma nd^3} = 36.4\mu$

With the aid of a table of squares, cubes, and fourth powers, the calculations involved are not prohibitively laborious.

Discussion

Table I and the curves in Figure 1 show the changes in the relative percentages of particles depending on the method of calculation. While 82% of the total number of particles are 2 microns in diameter, only 1.5% of the total volume or weight is represented by these particles. These differences are reflected in the different mean values.

Equation (1) is the numerical mean usually employed. It has no significance except as it means that the average diameter so calculated multiplied by the total number of particles in the sample will equal the summed diameters of the particles in the sample.

In equation (2) the term length is taken to mean the sum of the diameters of the particles of a given size.

Equation (3) gives a value for the average particle size which is to be interpreted as follows: A unit volume of material consisting of particles of this size only will have a total surface identical with that in a unit volume of the sample under investigation. Such a mean diameter seems a logical value to apply to paints, pigments and fillers since its use affords direct comparison of total surfaces in unit volume, or in unit weight (specific surface).[1] In comparing materials of different specific gravities it seems most logical to calculate average particle size as shown obtaining a value related to surface per unit volume. The specific surface or surface per unit weight may then be obtained by the relationship $d_{av.} = \frac{6}{S\rho}$.

Equation (4) gives a value of use in problems of ore or coal concentration. Here we assume that the amount of gangue remaining attached to the metallic ore or to the good coal is directly proportional to the diameter and to the weight of the particles, the *degree* of attachment being proportional to the diameter and the *quantity* to the weight. Thus the expression[2] Σyd where y is in weight per cent has been used in calculating mean diameters in connection with our work on the Trent Process of cleaning coal.

In each case, the average diameter is the mean value which would be obtained by integration of the curves shown in Figure 1. The occurrence of the fourth power of the diameter in equation (4) is difficult to interpret, but the value for mean diameter obtained by use of this equation has physical significance. In the example in Table I*b*, the value 36.4 microns in equation (4) indicates that one-half of the weight of the sample consists of particles 36.4 microns or less in diameter and one-half consists of particles 36.4 microns or greater. In other words, if there is a proportionality be-

[1] Specific surface, $S = \frac{6}{d\rho}$ where d is the diameter of particle and ρ the specific gravity of the material.

Average diameter, $d_{av.} = \frac{6}{S\rho}$ where S is the total surface in 1 gram of the sample.

$$\frac{6}{\Sigma(ys)\rho} \text{ where } y \text{ is weight per cent of particles of specific surface } s$$

$$= \frac{6}{\rho}\left(\frac{1}{\frac{\Sigma(nd^3 \cdot s)}{\Sigma nd^3}}\right) = \frac{6}{\rho}\left(\frac{1}{\frac{\sum\left(nd^3 \times \frac{6}{d\rho}\right)}{\Sigma nd^3}}\right) = \frac{\Sigma nd^3}{\Sigma nd^2} \qquad (3)$$

[2] y_1 = the weight per cent of particles of diameter $d_1 = \frac{n_1 d_1^3}{\Sigma nd^3}$

$$\Sigma yd = \sum\left(\frac{nd^3}{\Sigma nd^3} \cdot d\right) = \frac{\Sigma nd^4}{\Sigma nd^3}$$

tween the amount of mineral matter physically attached to pure coal and the fineness to which the coal is pulverized a sample of this coal in which the particles were all 36.4 microns in diameter would contain the same percentage of mineral matter attached to the pure coal as contained in the sample under investigation.

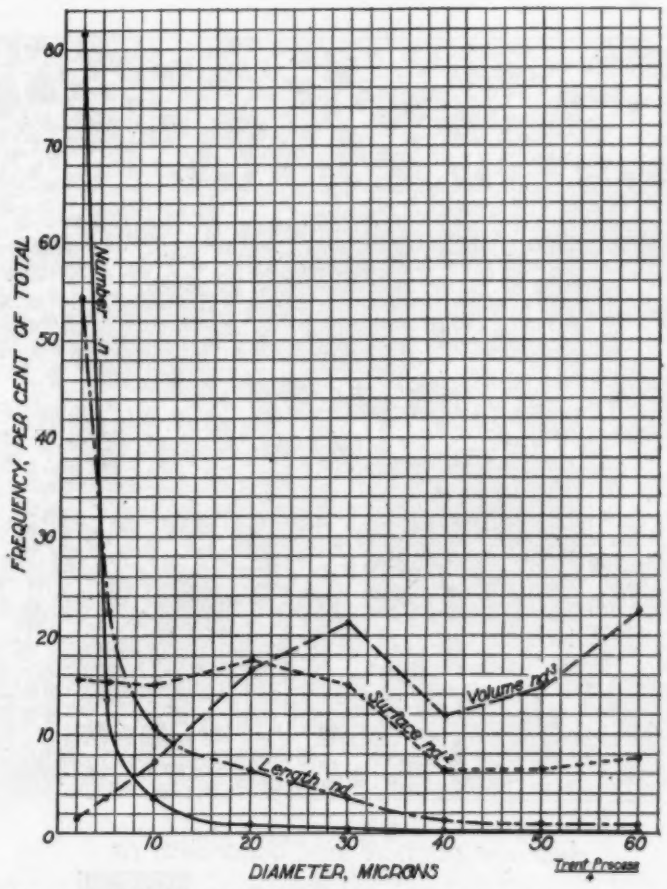


FIG. 1.—Graph showing distribution of particles in sample of pulverized coal according to percentage of total.

Mr. C. M. Bouton,[1] physical chemist of the Pittsburgh Experiment Station of the Bureau of Mines, has suggested the following explanation of the values obtained from equations (1), (2), and (3) in Table I*b*.

If the particles are dropped on a surface so that they do not roll after striking and if they are then moved into a single line without any rotation during the moving, the

[1] Private communication.

length of the line would be *nd* and the average length of the particles in the line would be 3.0 microns. If now, without altering the vertical depth of any particle, the irregularities in the line are smoothed out so as to make it of uniform width throughout, with the additional condition that the total exposed surface remain unaltered, the width of the line

Coal ground to pass a 200-mesh screen.
Magnification, 500 diameters
diagrammatic.

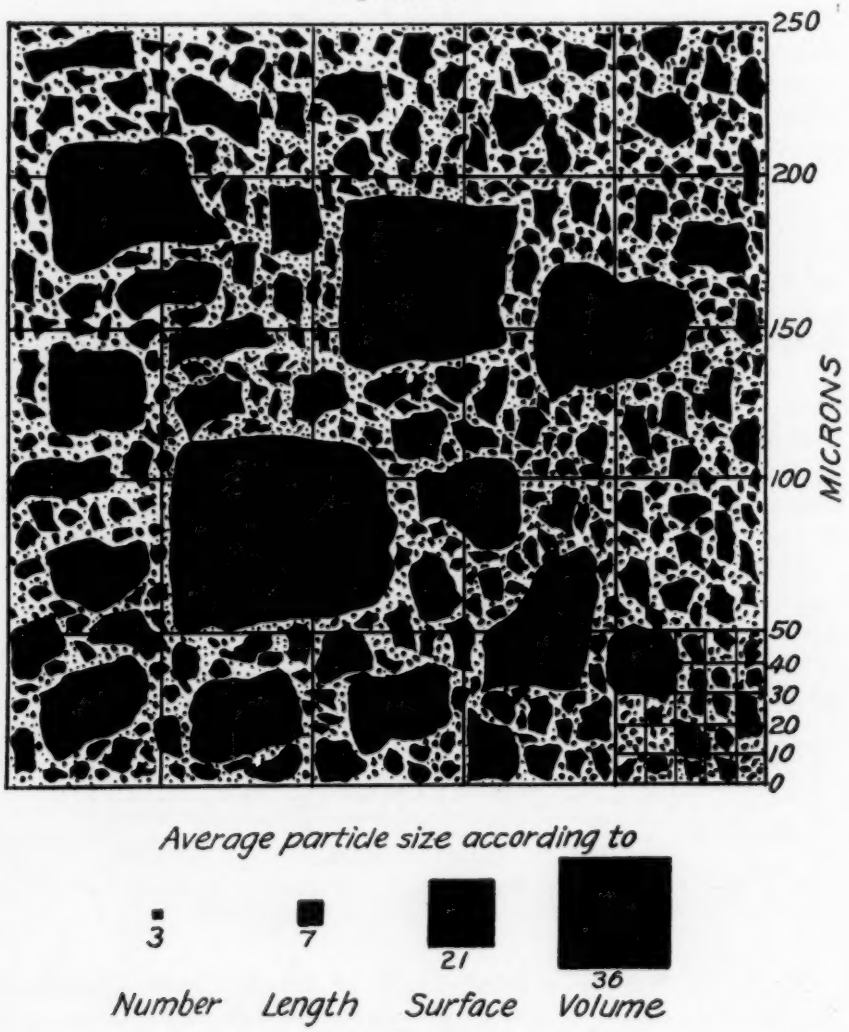


FIG. 2.

would be 7.0 microns. If the vertical inequalities were similarly smoothed out, the vertical depth necessary to give the true volume of the particles would be 21.0 microns.

Approaching the matter from this point of view, the average particle might be said to be one whose dimensions are $3 \times 7 \times 21$, or $l \times b \times t$, in which l is the average

length, $l \times b$ the average visible surface and $l \times b \times t$ the average volume. These three values considered together give an indication of the manner of distribution of the particles of various sizes.

The fact is, of course, that it is impossible to find a length, x, such that n equal cubes or spheres of diameter d will have the same total length, surface, and volume as any n fortuitous objects. The diameter d will inevitably be different according to the choice of length, surface, or volume as the valuable property of the objects. If but a single figure is given to represent the average particle it would therefore seem essential to specify whether the figure represents the average length, surface, or volume.

To the authors' knowledge, none of these methods of calculating average particle size have ever been applied to the results of a microscopic count, with the exception of the numerical method (1). The ceramists have calculated surface factors by multiplying the weights per cent of their elutriation fractions by the reciprocal of the diameter and have calculated average diameters by multiplying weights per cent of their elutriation fractions by the diameter itself, *i. e.*, surface factor $= \Sigma \frac{y}{d}$ and average diameter Σyd where y is in weight per cent. Thus their average diameters and surface factors are not comparable. It would seem logical to calculate average diameter and surface factor on the same basis, *i. e.*, average diameter = reciprocal of surface factor.

It should be borne in mind that the term average diameter is of little practical value unless carefully defined. The "average diameter" or "average weight" of a given number of cannon balls and lead shot are meaningless except as mathematical values. Sufficient shot might be cut out of one cannon ball to make the numerical average diameter or average weight or volume close to that of the shot. To have physical significance the term must be carefully qualified.

Figure 2 shows a graphical representation of the coal samples in Table I, together with the size of the average particle calculated in various ways. The absurdity of the numerical mean diameter is immediately apparent.

"Mellor's Mean" and Other "Means"

Various workers have proposed methods of obtaining the average particle size by calculation from the magnitude of the largest and smallest particles present. "Mellor's mean" has been widely used by ceramists in calculating the average particle size of their elutriation fractions. To quote Mellor:[1]

> The arithmetical mean of the limits cannot be the correct representative average for the numbers of a group containing a large number of particles. To obtain the true representative value it is necessary to sum the diameters of the indefinitely large number

[1] J. W. Mellor, "Jackson's and Purdy's Surface Factors," *Trans. Eng. Ceram. Soc.*, **9**, 94 (1910).

of particles in the given group and divide by the total number of particles in the group. This is impracticable by arithmetic. We therefore turn to the integral calculus which enables us to cope with the difficulty.

Mellor then gives the formula from the theorem of mean values:

$$\text{Mean } \frac{\int_b^a y dx}{a-b} \text{ where } y = f(x)$$

and proceeds to derive an expression for the average volume in a sample containing particles ranging from d_1 to d_2 in diameter.

$$\text{Average volume} = \frac{\frac{\pi}{6}\int_{d_2}^{d_1} x^3 dx}{d_1 - d_2}$$

$$= \frac{\pi}{24} \times \frac{d_1^4 - d_2^4}{d_1 - d_2}$$

Average diameter d of sphere with average volume $^1/_6\ \pi\ d^3$ will be

$$\sqrt[3]{\frac{d_1^4 - d_2^4}{4\,(d_1 - d_2)}} \quad \text{or} \quad \sqrt[3]{\frac{(d_1 + d_2)\,(d_1^2 + d_2^2)}{4}}.$$

Mellor assumes that his formula gives him the true arithmetical mean when the diameters range in an evenly graded[1] series between given limits. Actually, however, it gives him a diameter calculated from the mean volume. This will always be somewhat higher than a mean diameter calculated from a summation of the series of diameters divided by the number in the series, and it is a question whether such a mean has any significance other than a formula which gives slightly more weight to the larger particles. It is certainly not the true representative value as defined by Mellor in the quotation given above, which, contrary to Mellor's statement is simply the ordinary arithmetical mean.

Assuming with Mellor that the diameters range in an evenly graded series, it can also be shown by calculus that the mean diameter calculated from

(1) Number is $^1/_2 \dfrac{d_1^2 - d_2^2}{d_1 - d_2}$ or $^1/_2\,(d_1 + d_2)$

(2) Length is $^2/_3 \dfrac{d_1^3 - d_2^3}{d_1^2 - d_2^2}$

(3) Surface is $^3/_4 \dfrac{d_1^4 - d_2^4}{d_1^3 - d_2^3}$

(4) Volume is $^4/_5 \dfrac{d_1^5 - d_2^5}{d_1^4 - d_2^4}$ or approximately $\sqrt[3]{\dfrac{d_1^3 + d_2^3}{2}}$

[1] Meaning one particle of each size.

Thus the authors might add several more "means "to the already large number, did they believe any such expressions of value. Certain assumptions of continuity must always be made in deriving an expression for a mean value between limits. Our work with pulverized coal has failed to show any consistent distribution of sizes. Green[1] has found this to be true in his work with zinc oxide and has expressed the manner of distribution in a given sample by the precision or "uniformity" coefficient.

In a paper by Ashley and Emley,[2] data are given as to sizes of the elutriation residues of a Tennessee wad clay. The average diameters are calculated by various methods. The correct edge considered by these authors is $\frac{\Sigma\sqrt{l \times b}}{n}$, *i. e.*, the numerical mean diameter. We have taken from the curves their data on the number of particles of each size with sufficient accuracy for the purpose and have calculated the average particle size by (1) employing various "means" of the maximum and minimum diameters and (2) using the detailed data in Table II for calculation of the average diameter by the several methods previously described. Calculations from the data on the sample of pulverized coal have also been included.

TABLE II

DATA OF ASHLEY AND EMLEY[2] ON TENNESSEE CLAY

(Taken from Curves in their Fig. 4)

Can 2, diameter (microns)	No. particles	Can 1, diameter (microns)	No. particles
46.8	1	131	1
40	1	120	1
36	1	110	1
35	1	102	3
33	1	101	2
31	1	93	1
30	1	86	1
29	1	85	2
27	5	84	1
26	1	83	1
25	2	81	1
24	2	80	3
22	8	77	2
21	4	74	3
20	1	72	1
19	1	71	3
18	1	69	2
16	4	68	1

[1] *Loc. cit.*

[2] H. E. Ashley, and W. E. Emley, "Errors in Determination of Grain Size of Minerals," *J. Ind. & Eng. Chem.*, **3**, 87–91 (1911).

TABLE II (*Continued*)

Can 2, diameter (microns)	No. particles	Can 1, diameter (microns)	No. particles
15	1	67	3
14	2	65	1
12	3	63	1
10	3	61	3
6	3	59	2
..		57	3
..	..	56	3
..	..	54	1
..	..	53	1
..	..	45	2

Table III shows the wide range of values obtained by the different means and the difficulty of attempting to obtain a true mean diameter from any expression involving only the limiting sizes. If a "mean" must be used, the arithmetical mean is probably as good as any other.

The differences between the values for average particle size as calculated from number, length, surface, and volume are shown to decrease with decreasing disparity in the numerical quantity of various sized particles. Thus in the case of the sample of pulverized coal in which 82% of the total number of particles and but 1.5% of the total weight were 2μ in diameter, the average diameter according to number is 3.0μ, according to volume 36.4μ. In case of the clay elutriation fraction in can 1, the corresponding values are 74.8μ and 89.8μ, respectively.

Methods of Classifying Fine Particles as Used by Other Workers

Sieves cannot be used for sizing particles finer than 50μ. That portion of a sample which passes a 300-mesh screen must be sized by other means. Workers in ceramics, cement, flour, paint, and soils, have employed the following methods[1] (1) and (2), page 429.

TABLE III

CALCULATIONS OF AVERAGE PARTICLE SIZE

	Can 1[1]	Can 1[1]	Pulverized coal[2]
Maximum edge	131	47	60
Minimum edge	45	6	2
Arithmetical mean $^1/_2\ (d_1 + d_2)$	88	26.5	31
Geometrical mean $\sqrt{d_1 \times d_2}$	76.8	16.8	11.0

[1] See the following: Wiley, Harvey W., "Principles and Practice of Agricultural Analysis," pp. 200–226, Chemical Pub. Co., pp. 636 (1906). *Bull.* **38,** Bureau of Chemistry, Dept. of Agriculture, p. 60. *Bull. soc. Imp. des nat. Mos.*, [1], 324 (1867). Pearson J. C., and Sligh, W. H., "An Air Analyzer for Determining the Fineness of Cement," Bureau of Standards Technologic Paper No. 48, **1915,** 74 pp. Schurecht, H. G., *Jour. Amer. Ceram. Soc.*, **3,** 355–78 (1920).

Laschinger's mean $\frac{d_1 - d_2}{\log_e d_1 - \log_e d_2}$	80.3	19.9	17.1
Mellor's mean $\sqrt[3]{\frac{(d_1 + d_2)(d_1^2 + d_2^2)}{4}}$	94.5	31.0	38.2
Von Reytt's mean $\frac{0.87}{2}(d_1 + d_2)$	76.6	23.1	27.0
Mean of form[3] $^4/_5\left(\frac{d_1^5 - d_2^5}{d_1^4 - d_2^4}\right)$	105.8	37.6	48
Average particle size from the detailed data according:			
to 1. Number $\frac{\Sigma nd}{\Sigma n}$	74.8	21.0	3.0
2. Length $\frac{\Sigma nd^2}{\Sigma nd}$	80.1	24.8	7.0
3. Surface $\frac{\Sigma nd^3}{\Sigma nd^2}$	83.6	27.8	21.0
4. Volume $\frac{\Sigma nd^4}{\Sigma nd^3}$	89.8	30.9	36.4

(1) *Sedimentation.*—Descent of particles through a liquid at rest.

(2) *Elutriation.*—Moving column of fluid sufficient to neutralize rate of fall due to gravity for the size particle being carried over.

In our work, both sedimentation in water and elutriation with air and water have been employed. None of the methods have been found satisfactory for separation of fine particles, *i. e.*, 20–0 μ in diameter, nor have they been found particularly satisfactory for the separation of samples containing particles from 50–0 microns. Depending on the fineness of pulverization, elutriation of a 20-gram sample will take from 2 days to a week or more, and even then the fractions into which the sample is so divided always contain particles of considerable variation in diameter.

Inasmuch as a microscopic method of calculating the average size of each elutriation fraction was necessary, it occurred to us to endeavor to calculate the average size of the entire sample without resort to elutriation and compare the average size so obtained with the average size calculated from the results of elutriation of the same sample.

Microscopic Method of Classification Procedure.—In the microscopic method as finally developed, the sample is mounted in Canada balsam, diluted with about 20% xylol. A few drops of this mixture are placed on a piece of window glass and a small amount of the pulverized coal sample mixed with it until the particles are evenly disseminated in the balsam. Two slides 50 x 75 millimeters are used for mounting the sample. A

[1] Data of Ashley and Emley, *loc. cit.*

[2] Data of authors.

[3] See p. 426.

drop of the mixture of Canada balsam and coal is placed on the clean slide. The coal in this mixture should weigh about 0.002 gram. A second thin slide is placed on top of the drop and the slides gently pressed together and slid back and forth until there is an even distribution of coal and balsam. The mixture should cover a circular space about two inches in diameter. By means of this method it is possible with a little practice to spread the drop evenly and secure an even distribution of the particles of coal.

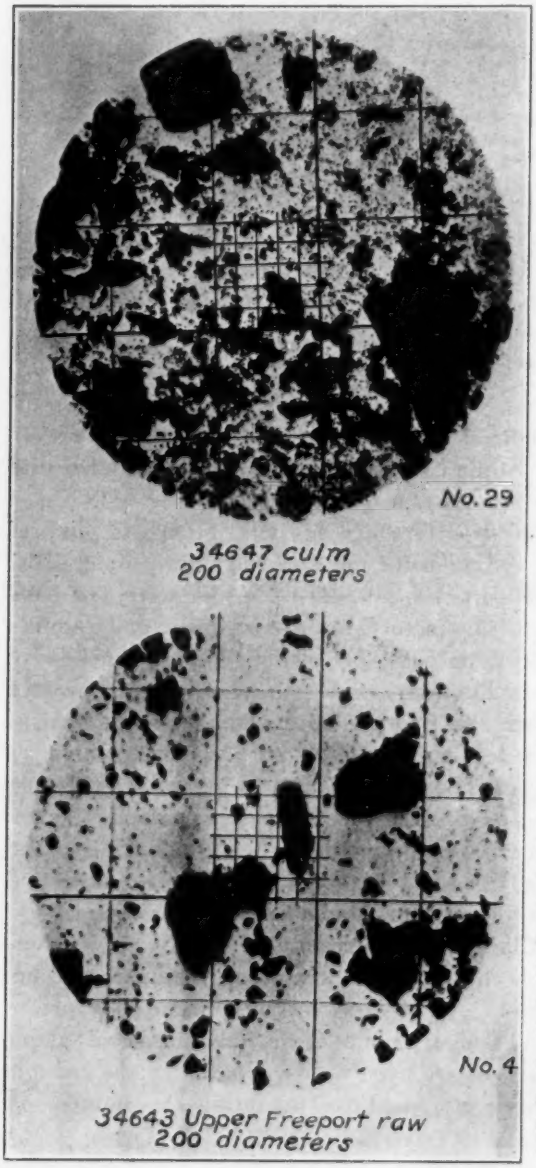


FIG. 3.

The microscope is provided with a micrometer eyepiece, the smallest divisions of which are 10 microns at a magnification of 200 diameters and $4^1/_2$ microns at a magnification of 500 diameters. A magnification of 200 diameters is usually employed.

Figure 3 shows the appearance of the field of the microscope so equipped.

In making the determination, the microscope is first focused on an area at one corner of the slide and the total number of particles in a quarter field counted, making note of the size of each particle. In our work the "size" or "diameter" of the particle has been taken as the side of a square having similar area. This "squaring" of the particle is carried out visually with

the aid of the squared ruling of the eyepiece. Such procedure is approximate but probably gives values as nearly correct as any method can give on the irregularly shaped particles.

In making this count particles are grouped as being 1, 2, 5, 10, 15, 20, 30, 40, etc. microns in diameter. Our practice has been to count the number of largest particles first. Sufficient areas are examined so that a fair average of the number of particles of each size in a quarter field is obtained. For a sample of coal which has been passed through a 200-mesh screen, this will entail estimation of the number of particles 2 and 5 microns in diameter in about 10 areas, 10 and 15 microns in diameter in some 40 areas, 20 and 30 microns in diameter in some 100 areas, while as many as 300 separate areas may have to be examined for a correct estimation of the average number of particles 40 microns and over.

Calculation.—An example of the method of calculation is given below:

Diameter in microns	Average number of particles in a quarter-field
20	1
15	3
10	40
5	110

	Rel. weight	Per cent by weight
1×20^3	8000	11.1
3×15^3	10125	14.1
40×10^3	40000	55.6
110×5^3	13750	19.2
Total relative wt.	71875	100.0

	Micron
0.111×20	2.2
$.141 \times 15$	2.1
$.556 \times 10$	5.6
$.192 \times 5$	1.0
Aver. size	10.9

In routine calculation it is more rapid to make the calculation as indicated by the expression $\frac{\Sigma nd^4}{\Sigma nd^3}$ which gives a value identical with that obtained above.

A sample data sheet showing an actual determination on a sample of anthracite culm, 200 mesh, follows:

TABLE III*a*

SAMPLE DATA SHEET SHOWING METHOD OF ESTIMATING AVERAGE DIAMETER

Number of Particles in a Quarter-field							
60u	50u	40u	30u	20u	10u	5u	2u
..	1	1	3	3	4	10	..
..	1	1	1	4	..	19	165
1	..	1	2	6	6	28	..

TABLE IIIa (*Continued*)

60u	50u	40u	30u	20u	10u	5u	2u
..	1	1	2	1	2	9	140
1	1	1	3	2	4	20	..
..	1	1	2	4	9	12	150
1	1	1	2	4	5	16	..
1	1	1	2	4	3	43	140
1	1	..	2	3	6	36	150
1	1	1	2	6	8	28	140
1	1	1	2	4	6	44	..
1	..	1	2	3	6	40	..
1	1	1	2	5	5	18	160
1	1	1	..	5	12	56	..
1	1	1	1	5	4	33	165
1	1	1	2	2	8	13	..
1	1	1	2	1	7	26	..
1	1	1	3	2	4	14	..
1	..	1	2	6	6	26	160
1	1	1	2	1	5	30	..
..	..	..	2	4	13	..	..
1	1	1	4	3	10	19	190
..	1	..	2	6	7	32	..
1	1	1	2	4	8	..	150
1	..	1	4	3	8	..	..
..	1	1	1	4	10	30	..
..	..	2	1	3	4	..	..
1	1	1	..	5	8	19	..
..	1	1	2	3	5	..	..
..	1	..	2	2	4	26	..
(*a*) Total number of particles in fields counted.....	21	24	28	59	105	187	666	1715
(*b*) Total fields counted	230	240	180	90	60	30	26	11
Average no. of particles per field $\left(\frac{a}{b}\right)$.....	.087	.100	.156	.66	1.75	6.2	25.6	155

Calculations

No. particles per field	Diameter microns	$d^4 \times$ No. $\times 10^6$	$d^3 \times$ No. $\times 10^6$	% Each size by weight
0.087	60	1.127	0.0187	22.4
.100	50	.625	.0125	15.0
.156	40	.400	.0100	12.0
.66	30	.531	.0177	21.2
1.75	20	.280	.0140	16.8
6.2	10	.062	.0062	7.4
25.6	5	.016	.0032	3.8
155	2	.022	.0012	1.4
		3.043	.0835	100.0

Average diameter $= \frac{3.043}{.0835} = 36.4$ microns

Comparison with Results of Elutriation

It was now necessary to compare our results with those obtained by elutriation. A simple water sedimentation apparatus and an air elutriation apparatus were used. Figure 4 shows the air elutriation apparatus. This apparatus is modeled after that of Pearson[1] with certain modifications. The most important change in the apparatus of Pearson has been the addition of a flowmeter, thus doing away with the necessity for different orifices at different rates of flow and eliminating the errors due to changing back pressure as discussed by Pearson. The rubber sheet and tapper at the bottom of the coal reservoir serve to prevent packing of the finely powdered coal, a device designed by Pearson[2] after publication of his

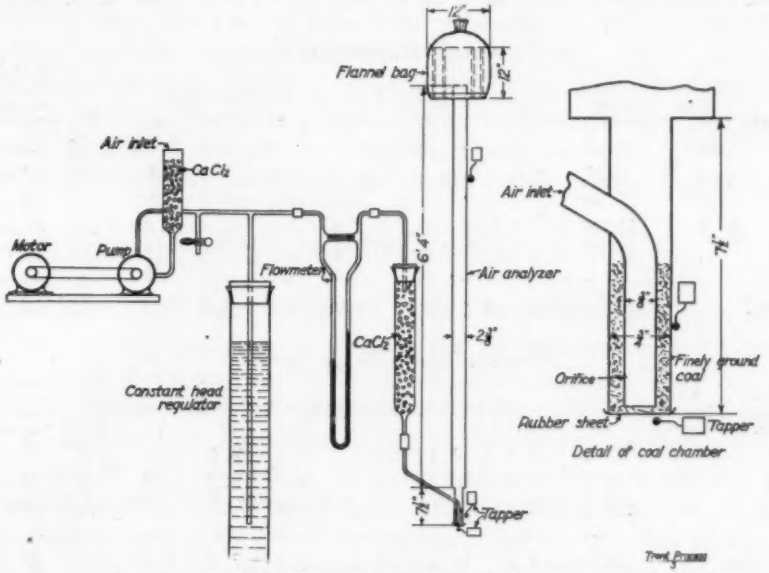


FIG. 4.—Air elutriation apparatus for finely ground coal.

paper. A Shulze water elutriation apparatus was not available, and a simple vertical tube elutriator was not found to give good results.

In Table IV a comparison is given of the results obtained by elutriation, sedimentation, and microscopic estimation of the original sample. All weights are given in percentages of the original sample. The calculated average diameter of the particles as calculated from air elutriation data was 32.0 microns, from water sedimentation data 32.5 microns, and from microscopic estimation of the original sample, 35 microns. This latter value agrees fairly well with the values from sedimentation and elutriation considering the difficulties of the experimental procedure.

[1] J. C. Pearson, and W. H. Sligh, *loc. cit.*

[2] J. C. Pearson, Private communication.

TABLE IV

COMPARISON BETWEEN RESULTS OF AIR ELUTRIATION, WATER SEDIMENTATION, AND SINGLE COUNT OF GROSS SAMPLE

Air Elutriation

Fraction	Linear velocity of air, mm./sec.	Wt. of total fraction, per cent	% Weight of particles of various diam. 60	50	40	30	20	10	5	2	Calculated average diameter, microns
1	8.7	17.6	..	..	..	..	2.0	6.5	7.18	1.90	8.2
2	11.3	21.6	..	..	..	4.6	10.5	3.9	2.13	.48	18.0
3	20.2	4.9	..	..	..	.9	3.0	.3	.61	.03	19.4
4	25.3	16.7	..	4.5	3.7	5.5	2.6	.34	.06	.03	35.6
R	..	39.2	16.7	11.1	7.3	3.2	.7	.07	..	..	50.2
Total		100.0	16.7	15.6	11.0	14.2	18.8	11.1	9.98	2.44	32.0

Water Sedimentation

Fraction	Time settled, min.	Wt. of total fraction, per cent	% Weight of particles of various diam. 60	50	40	30	20	10	5	2	Calculated average diameter, microns
1	25	9.12	..	..	..	..	1.8	2.4	2.75	2.17	8.5
2	15	7.27	..	..	..	.2	1.4	2.2	2.56	.91	9.9
3	10	17.38	..	..	..	3.7	5.1	6.5	.83	1.25	16.3
4	5	23.06	..	1.7	13.3	3.8	2.4	1.4	.38	.08	37.4
R	..	43.17	13.4	10.7	8.5	6.4	3.2	.8	.15	.02	45.0
Total		100.0	13.4	12.4	21.8	14.1	13.9	13.3	6.67	4.43	32.5

Original Sample, Single Count

Determination No.	Wt. of total fraction, per cent	% By weight of particles of various diameters 60	50	40	30	20	10	5	2	Calculated average diameter, microns
1	100	13.2	13.2	19.5	22.4	16.5	9.4	4.4	1.3	33.6
2	100	18.4	18.9	15.2	17.1	19.0	7.2	3.3	1.0	24.9
3	100	25.2	13.5	14.1	15.2	20.0	7.1	3.7	1.3	36.6
Average		18.9	15.2	16.2	18.2	18.5	7.9	3.7	1.3	35.0

TABLE V

DETERMINATION OF AVERAGE PARTICLE SIZE OF A MIXTURE

(1) By separate examination of the components of the mixture.

(2) By examination of the mixture.

Mixture No. 1

Components No.	Wt. per cent	Wt. per cent of particles of various diameters 60	50	40	30	20	10	5	2	Calculated diameter, (microns)
a	17.6	..	..	..	..	2.0	6.50	7.18	1.90	8.2
b	21.6	..	..	..	4.6	10.5	3.90	2.13	.48	18.0
c	4.9	..	..	..	.9	3.0	.30	.61	.03	19.4
d	16.7	..	4.5	3.7	5.5	2.6	.34	.06	.03	35.6
e	39.2	16.7	11.1	7.3	3.2	.7	.07	..	..	50.2
Total (1)	100.0	16.7	15.6	11.0	14.2	18.8	11.11	9.98	2.44	32.0

Mixture, Single count (2)	19.7	15.6	11.7	11.3	21.0	14.4	5.0	2.30	33.4

Mixture No. 2

Components No.	Wt. per cent	Wt. per cent of particles of various diameters									
		60	50	40	30	20	10	15	5	2	
a	50	11.1	7.0	6.8	8.9	7.1	2.1	4.2	2.2	.6	35.7
b	50	..	..	..	5.8	5.2	7.0	18.6	9.7	2.6	12.5
a + *b* (1)		11.1	7.0	6.8	14.7	12.3	9.1	23.8	11.9	3.2	24.2
By single count (2)		9.6	10.1	10.1	17.4	16.3	..	17.4	13.7	5.6	25.9

Synthetic Mixtures

Due to loss of some 5 to 10% of material during elutriation procedure, further comparative work was done on synthetic samples prepared by mixing appropriate weights of elutriation fractions or other samples of varying degrees of fineness. These synthetic samples served as the unelutriated material and a determination of the average particle size was made upon these samples for comparison with the value calculated from the average particle size determined on the various components of the mixture.

Table V shows the agreement obtainable.

Weight Calculated from Microscopic Data

As a further check on the method, the attempt was made to estimate the weight of the coal sample spread on the microscope slide. This necessitated determination of the total number of particles of various sizes. The usual method of procedure gives us the average number of particles of each size in a quarter of the field of the micrometer eyepiece. The area of this field for a given magnification is known. The area covered by the sample may be measured by means of millimeter ruled paper. The weight of the sample is then $\frac{v\rho A}{f}$, where v is the volume of the particles in a quarter field, ρ the density of the material, A the area covered by the sample, and f the area of a quarter field. Obviously, $v=\Sigma nd^3$, where n is number of particles of diameter, d.

A known weight of material was put on the slide by the following procedure: A thin slide of dimensions 50 x 75 mm. is weighed on an assay balance; 0.002–0.004 g. of coal is placed on the slide and weighed. A drop of the Canada balsam-xylol mixture is placed on the slide and mixed with the coal by means of a fine quill, any material remaining on the quill being spread on the cover slide. The cover slide (50 x 75 mm.) is then placed on the drop and the slides pressed together and slid back and forth until the mixture is evenly distributed and covers an area of 1 to 2 square inches. Microscopic examination is made as previously described.

TABLE VI

WEIGHT CALCULATIONS FROM MICROSCOPIC DATA

Anthracite Coal

Sample	Number of particles in 1/4 field (x10³)															Av. diameter d (microns)	Area of slide covered by sample, mm.²	Wt. of coal on slide (grams)		Ratio b/a	Remarks
	200μ	150μ	100μ	75μ	60μ	50μ	40μ	30μ	20μ	15μ	10μ	8μ	5μ	2μ	1μ			Actual a	Calculated b		
I																					
Ground dry to pass	62	81	119	400	..	1050	...	2020	5100	..	1110	...	...	....	...	134	380	0.0023	0.0036	1.56	A
a 65-mesh screen	45	122	275	206	..	970	...	1860	3000	..	1330	...	...	....	....	129	346	.0023	.0034	1.48	A
II																					
Ground dry to pass	..	...	...	...	48	65	95	218	1020	1350	5200	...	21600	152000	...	33.4	2821	0.0036	0.0043	1.19	B
a 200-mesh screen	..	...	...	...	68	64	172	450	910	700	5900	...	26400	102000	...	36.4	3145	.0039	.0060	1.54	B
	..	...	...	...	97	94	208	666	1460	1280	6900	...	28700	177000	...	36.0	1055	.0019	.0028	1.47	B
	..	...	...	...	87	100	156	655	1750	..	6200	...	25600	155000	...	36.4	1069	.0015	.0027	1.80	B
III																					
Material through 200 mesh ground 6 hours wet in ball mill	..	...	...	...	..	..	...	33	86	414	4940	...	20500	40000	...	11.6	1237	0.00127	0.00190	1.49	C
IV																					
Material through	..	...	...	...	..	..	...	..	..	100	360	480	3200	15200	70000	8.5	1362	0.000170	0.000291	1.71	C
200-mesh ground	..	...	...	...	..	..	...	..	..	85	200	340	2900	18000	74000	8.1	1371	.000173	.000239	1.38	C
30 hours wet in	..	...	...	...	..	..	...	..	..	44	300	550	2000	13100	54000	7.9	1334	.000121	.000216	1.80	C
ball mill	..	...	...	...	..	..	...	..	..	63	183	224	1590	13100	59000	8.2	1249	.000098	.000153	1.56	C

Remarks: A.—Magnification, 100 (area of 1/4 field 0.25 mm.²).
B.—Magnification, 200 (area of 1/4 field 0.0625 mm.²).
C.—Magnification, 500 (area of 1/4 field 0.0127 mm.²).

With very finely divided material this procedure gives a field containing too many particles per unit area for easy counting. In such a case, a Canada balsam mixture containing a known weight per cent of coal is made up in a weighing bottle and a known weight of the mixture placed on the slide. This latter procedure was followed in the determinations on sample IV in Table VI. The true specific gravity of the coal used was 1.815.

Considering the difficulties of the procedure, the agreement between actual and calculated weights is good. The calculated weight is always higher than the actual weight due undoubtedly to the fact that the procedure builds a cube around the irregularly shaped particles and thus indicates a volume larger than the actual volume. Since, however, the ratio b/a does not change progressively with change in size of the particle, the values for percentage weight of each size and for average particle size should agree with values determined by elutriation procedure.

In making the following measurements of length, breadth, and thickness, the sample was spread on the slide with xylol which was then allowed to evaporate. No cover glass was employed. The measurements of length and breadth were made by means of the micrometer eyepiece. Measurements of thickness were made by focusing on the top surface of the slide and then on the highest point of the particle. The difference in the two readings on the micrometer focusing screw was called the thickness of the particle.

TABLE VII

MEASUREMENTS OF LENGTH, BREADTH AND THICKNESS

Estimated edge	L	B	T	Average edge $\frac{L+B+T}{3}$	No. of particles measured
			Anthracite Coal		
50	60	40	39	46	18
30	32	24	25	27	18
20	18	16	16	17	19
10	10	8	6	8	18
5	5	4	7	5	13
			Bituminous Coal		
50	57	35	54	49	19
30	30	24	26	27	19
20	19	15	20	18	19
15	13	12	17	14	13

The dimensions given are numerical averages, and the average edge has been taken as $\frac{L+B+T}{3}$. This figure differs little from $\sqrt[3]{LBT}$ or from $\frac{\sqrt[3]{lbt}}{n}$, where l, b, t are dimensions of an individual particle and n the number of particles measured, due to the fact that the dimensions are not widely different.

It will be seen that the average edge so determined is slightly less than the estimated edge determined by the visual method of "squaring" the particle as previously described.

Summary

The term "average particle size" is capable of various mathematical interpretations, many of which have little practical significance. The usual statistical method of calculation from microscopic data considers only the numbers of particles of a given size in determining the average diameter. Thus, the weight of a particle of a given diameter in the general average is determined by its frequency of occurrence or its numerical percentage of the total number.

In practice it is difficult to dissociate a particle from its surface or volume. We find other values for mean diameter when we substitute for numerical frequency of occurrence, the per cent of the total surface or of the total volume (or weight) represented by particles of the respective sizes.

The value for effective average particle size suggested for ceramic materials, fillers, and pigments is obtained from the following expression: $d_{av} = \frac{y_s d}{100} = \frac{\Sigma n d^3}{\Sigma n d^2}$, where y_s is the per cent of total surface represented by particles of diameter, d, and n is the relative number of particles of diameter, d.

The value for effective average particle size suggested for use in problems of ore or coal concentration is $d_{av} = \frac{\Sigma y_v d}{100} = \frac{\Sigma n d^4}{\Sigma n d^3}$ where y_v is the per cent of total volume represented by particles of diameter, d.

These values for average particle size have practical significance. Thus mean diameters calculated from surface are related inversely to the specific surface of the material and are of value to ceramists and other workers where the total surface exposed per unit volume or weight of material is of importance. Mean diameters calculated from volume show the region in which the average weight of material is concentrated and are of value in problems of ore or coal concentration.

It is believed that microscopic measurement of the size of particles in a sample of pulverulent material may be employed in place of elutriation with a considerable saving of time. Data obtained by elutriation and microscopic measurement of pulverized coal have been submitted.

A rapid method of microscopic measurement has been described which gives results sufficiently accurate for many purposes, and should be of value to workers in ceramic materials and fillers. A subsequent article will discuss the extent of separation of mineral matter from coal at different degrees of pulverization.

Acknowledgments

This investigation was conducted under the direction of A. C. Fieldner, Supervising Chemist, Pittsburgh Experiment Station, Bureau of Mines. Our thanks are also due to C. M. Bouton, Physical Chemist, and John Blizard, Fuel Engineer, Pittsburgh Experiment Station, Bureau of Mines, and to Henry Green, New Jersey Zinc Company, Palmerton, Pa., for reading and criticism of the first draft of this paper, and to W. N. Weigel, Mineral Technologist, Bureau of Mines, for advice and criticism during the writing of the paper.

COAL AND COAL PRODUCTS LABORATORY
CHEMICAL DIVISION
PITTSBURGH EXPERIMENT STATION
BUREAU OF MINES

SCHEDULING IN A TERRA COTTA PLANT

By Pensyl Mawby

In order to understand the problems of control in a terra cotta plant it is necessary to know something of the industry itself. Terra cotta, or as the name implies, burned clay, is made by molding or modeling suitable clay into the desired shape and baking to secure hardness. The method is very simple in theory and in practice and has been used in all the ancient civilizations.

Terra cotta in some form has been found in the ruins of every seat of ancient culture. As early as 500 B. C. the Egyptians were making clay slabs, decorating them with some form of crude art, and baking them. The Greeks used highly decorated figures in their temples. Terra cotta for purely architectural purposes also came into use. However, the material evidently fell into disuse in the Dark Ages owing to the inrush of barbarism, as medieval records contain no mention of the product.

It can be truthfully said that the present age of the product dates back to only the last twenty years, for it is within that time that discoveries and refinements in process have been made which have placed its manufacture on a stable base, eliminated much of the wastes and other losses, and made it an industry capable of holding its own in modern competition. The terra cotta business is now on a firm foundation.

As stated before, the process is simple. Clay and ground bits of fine brick, porcelain ware, etc., called "grog" form the principal raw materials. The clay is taken from the storage bins and run through a continuously operated chain of machines known collectively as the mixer. In the mixer, the clay is first ground to a fine powder after which it is removed and sifted to eliminate all foreign matter. Grog and water are then added in the "pug" and the material thoroughly mixed. The clay comes out of the pug on a moving belt ready for use. If it is not needed for immediate use it is stored in bins adjacent to the main room until needed.

In the making of intricate pieces of artistic shapes and design, the clay is modeled by an expert modeler. In the case of pieces to be duplicated, the work is much similar to the work in a foundry. Suitable molds of collapsible type are made and the clay pressed into them by hand.

The pieces of terra cotta, whether modeled or molded, are not ready for the next step in the process until they have been allowed to stand and dry some thirty-six hours. After the pieces are dried, a chemical preparation, called "slip," or glaze, is sprayed on to produce whatever color or glaze effect desired. The pieces are now carried to the kilns where they are burned at a steadily increasing temperature for a period of from three to six days after which the terra cotta is ready to be inspected, fitted, and shipped.

Too much stress cannot be laid on the fact that this is essentially a hand labor one. Machines have not yet been invented which can supplant the

hand labor. It is also an industry which has very little standardization. With the exception of quality and workmanship, we may say it is entirely without standardization. Rarely are two buildings ever alike. The design differs, the plan differs, the color or finish differs and last, but not least, the size of the blocks vary. These factors make each job entirely different from that which preceded it, therefore, each job will require not only a different treatment but also a varying length of time to go through the factory. All these factors necessitate some adequate system of control. The superintendent, since he is able only to approximate the time needed, will want to know at all times just where his production is, if it is up to schedule and just what jobs need to be pushed. He should be able to plan ahead all the factory moves.

FORM 61

TO THE SUPERINTENDENT

FOLLOWING SECTIONS PUT IN HAND OR OUT TODAY

DATE ..... DEPT. .....

ORDER NO.	SECTION	IN	OUT		REMARKS

.....
DEPT. FOREMAN

FIG. 1.

The system of control employed at present consists simply of having the foreman report to the main office on the form shown in Fig. 1 as soon as a section of the job, or order, goes out of his own department. No record is made of the date the section entered the department as it is assumed that this date will, in all cases, be the same as the date on which it left the preceding department. These "out" dates are then entered on the form as shown in Fig. 2 and the form is placed in a loose leaf note book, kept in the superintendent's desk.

No attempts are made to schedule the work. In addition there is no way of checking the progress of production except by laborious review of the production book in the superintendent's desk.. Furthermore, the superintendent does not know whether the job is in production or not because, as was previously pointed out, the dates are entered after the production in that particular department is finished.

A scientifically constructed control system should require as little labor as possible for its operation yet provide the essential information necessary

to call the superintendent's attention to the items which need his attention. It is the writer's belief that the system proposed in the following pages will satisfy these requirements.

This system is composed of a main graph board constructed to hang on a wall in such a way that all parts are easily reached and the various devices changed. The backing is to be of wood of sufficient thickness to give stability and serve for a firm foundation. Covering the wood is a thickness of heavy cork linoleum into which pins can be pushed with little effort. This cork facing is painted white, without varnish. A frame at least three inches in depth should be provided to serve as protection, otherwise the various symbols might be brushed off. The accompanying blue print is to be used for reference. The boxed numbers

	BUILDING			COLOR								
	LOCATION			SURFACE								
	ARCHITECT			ORNAMENT				SPEC. JOINT				
	DELIVERY TO			EST. TONNAGE				EST. MOULDS				
	ORDER	SECTIONS	ARCHITECTS DRAWINGS	REMARKS (FIG. 2)								
	FEATURE		SECTION	NO. PIECES	D.O.	M&M	MOD.	P&F	KILN	FIT.	SHIP	DATE OF SHIP.
			A									
			B									
			C									
			T									
			U									
			V									

FIG. 2.

thereon refer to the numbers cited in these instructions. The caption headings, lines, divisions, etc. should be painted on the white surface in the proper places.

Under the caption "Order" as shown in the figure, are three columns marked "Number," "Section," and "Pieces." In these columns are brass name plates No. (1) constructed so that label cards may be shown in them. In those name plates in the column marked "Order" will be given the order number of the job. In the plates in the "Section" column will be the section letter of a portion of the order and in the "Pieces" column will be the number of pieces to that section.

The sections of the order then are shown between the horizontal lines across the board while the departmental divisions are shown by the vertical lines.

In a space between the "Pieces" column and the next, marked "Model

Making" are set tapes on spring spools as shown on the chart by No. (2). In the free end of each tape is a tack which will hold the end of the tape in position as it is drawn across the board through the departmental column to the right. Production progress of each section of an order through the various departments will be indicated by drawing the tape to the proper columnar position.

These columns, as is shown, represent the Model Making Department, Modeling Department, Molding Department and the Pressing and

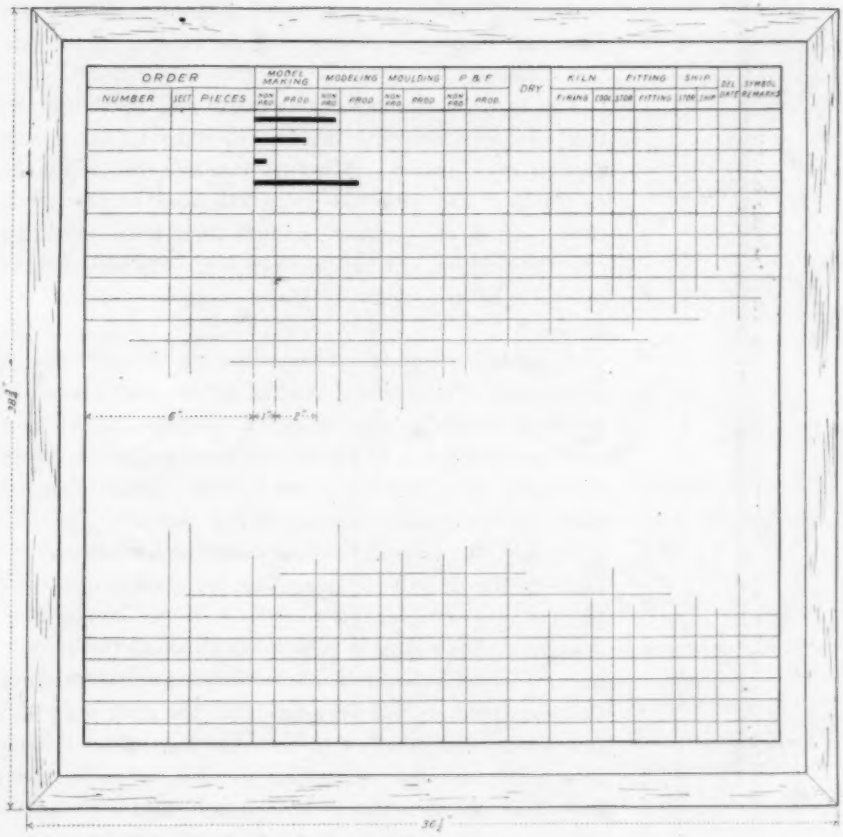


FIG. 3.

Finishing Department. It will be noted that these departments are subdivided into two columns, one marked storage, or "non-production," and the other marked "production." By using these columns it will be possible for the graph tape to show whether the section is actually in production or not in that particular department. It is also suggested that the tape be moved through varying degrees in the production column so as to show the progress of the work. For example, if the tape is drawn half

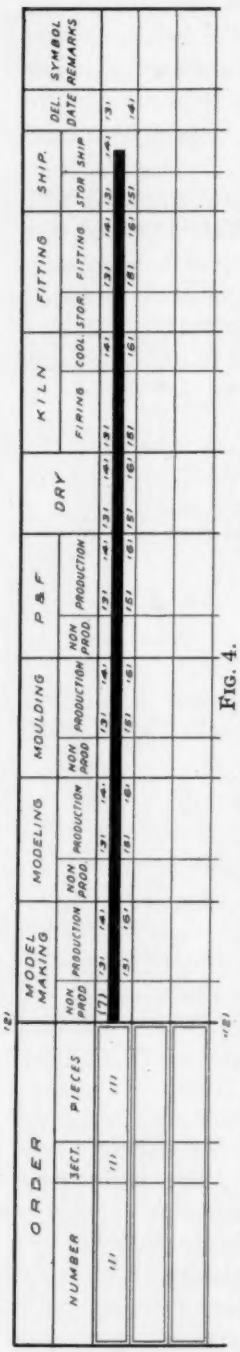


FIG. 4.

way across the production column in the Pressing and Finishing Department it signifies that the work is 50% completed here.

The next division, or column, is marked "Drying" and represents a non-production department. The kilns follow. This is also divided into two columns, one for firing and the other for cooling in the kilns. The "fitting" is the last departmental column and is divided into "Storage" and "Shipping." If the goods are in process of shipping the tape is drawn into this column.

The tape should never reach the end until the section has been shipped in full. This is as far as the tape is ever drawn. When it reaches this point the section of the order is complete and the symbols, cards, tape, etc., removed and the space used for another section. A column has been provided for the notation of the delivery date as is shown on the figure.

A collection of colored faced thumb tacks should be provided. The colors should be seven in number. In addition to being colored, six of the sets should have numbers from one to thirty-one stamped on the faces. The other set is numbered one to nine. Each of the six colors will represent two months, *e. g.*, January and July, February and August. The numbers will represent the date in the month. These date pins will be placed in the corners of all departments as shown in the Figs. 3 and 4. The work is scheduled through the factory and its various departments with reference to the final delivery dates. No. (3) represents the date on which the job is scheduled to go into the department while No. (4) is the date on which the job actually comes in. The columns marked "Symbol" and "Remarks" are reserved for symbols to show the reason for any delay and remarks on that delay.

The following is an example of how this chart would work. Order number 1432, Section A has been accepted by the plant for manufacture. It contains 132 pieces. The order number, section letter and the number of pieces therein are placed upon the board in the name plates. The proper delivery date is shown in the provided column. The work is scheduled

through the various departments and the scheduled dates are shown by means of pins mentioned. Only "In" dates are shown since the "In" dates of the following department should correspond to the "Out" dates of the preceding department.

The tape advances into the Model Making storage column and the actual "In" pin is placed at No. (7) when the work is released from the draughting office. When production is begun the tape is moved into the production column and the actual "In" pin is placed at No. (4). Upon completion the tape is moved into the next department and the "In" pin posted. Comparisons of the two date pins will show whether or not the job is up to schedule and if not, it will show exactly which department is at fault. These comparisons can be easier made if more pins are used. In this case the "Scheduled In" pins would be placed at No. (3) and the "Scheduled Out" pins at No. (5). A subtraction of the two dates can easily be made and the scheduled time computed. The "Actual In" pin would then be shown at No. (4) and the "Actual Out" pin at No. (6). In this way not only can computations be easier made but mistakes be avoided. The latter, or four pin method, will probably prove the best since by it can be shown conditions impossible to show satisfactorily on the other, *e. g.*, when some pieces are advanced to the next department before the job is finished in the preceding. In this case the "Actual In" pin will be placed in the second department as soon as the first piece is worked on. The "Actual Out" pin will not be placed in the first department, nor the tape advanced until the order is complete in the first. If the seventh colored pins are numbered from one to nine they can be placed in the space normally occupied by the tape, in the proper

FORM G1A

TO THE SUPERINTENDENT

FOLLOWING SECTIONS PUT IN HAND OR OUT TODAY

DATE ..... DEPT. .....

ORDER NO.	SECTION	IN	OUT	S/A	REMARKS
		(1)	(2)	S	
		(3)	(4)	A	
				S	
				A	
				S	
				A	
				S	
				A	
				S	
				A	
				S	
				A	

..... DEPT. FOREMAN

S = Schedule
A = Actual

FIG. 5.

combination, to show the number of pieces so advanced. This will save much confusion in practice. The four-pin system will also allow the condition of such sections to be shown which are finished in the preceding department, yet are being held in storage in the next department. The time would not be charged against this department as would be under the two-pin method.

One of the chief duties of the clerk responsible for posting of the board will be to see that orders are not falling behind the schedule. If this should take place, he will immediately place a red card in the symbol column. This feature is not to be neglected for it is one of the most valuable. It will serve to draw attention to this particular order section and the tag should not be removed until the conditions are remedied. There is nothing at present, so far as the plans have gone, to prevent the officers on charge, scheduling more work in a department than its capacity will warrant. A small auxiliary chart will remedy this condition. A spring tape chart, or graph, such as has already been described could be used. The four departments, modeling, molding, pressing and finishing and the kilns should be shown as were the orders and sections. The departmental space would be done away with and a percentage scale substituted. In this case the tape will be drawn across to the percentage of capacity which is scheduled for each department. Since the main chart will show exactly which orders are scheduled for that week it is not necessary to show this information on the capacity chart.

Some very slight changes should be made in the method of reporting. The present foreman's report should be made in triplicate in the main office. The date of report, department, order number and section should be filled in by the office clerk before being sent to the shop. He will also fill in the "Scheduled In" and "Scheduled Out" dates as shown on Fig. 5 by the note figures No. (1) and No. (2). Two copies will then be sent to the foreman. The third should be kept on file. The foreman will enter "Actual In" date at No. (3) when the section starts production in that department and send the report to the main office immediately for entry. When the section is completed the foreman will enter the "Actual Out" date at No. (4) and send the form into the office. It should be noted that these forms must be sent to the foreman several days before the section is scheduled to start that the receipt will serve as an order to produce. These reports will, of course, serve as the basis for entry on the main board.

It will not be necessary to make any other entries because the board will give all information at the time. However, the form as shown in Fig. 2 could be kept as a permanent record. The dates of "Scheduled In," "Scheduled Out," "Actual In" and "Actual Out" should all be kept instead of only the "Actual Out" date as is done at present.

The advantages of the proposed system are obvious. The work can be scheduled more closely to maximum output in the various departments and in addition each department will know exactly how it stands and what work is ahead. The superintendent can tell at a glance how production is progressing and know which sections or jobs need his attention. It will not be necessary for him to review a mass of figures in order for him to know the conditions.

Under the proposed system of control, the work is anticipated and the foreman and men can make good use of the advance information. There is every reason to believe that a friendly rivalry will spring up between departments and an attempt made to prevent orders being delayed. This stimulation certainly would be healthy.

Another advantage is that each foreman will receive a written order as his authorization to proceed. Likewise he will be relieved of the necessity of planning orders, a function which essentially belongs to the management.

Not only are all the advantages derived in the plant itself, but some will be found on the outside. There is much less chance of running over delivery dates which in itself is a very important item. A plant which has the reputation of shipping the goods when promised has a reputation of which to be proud. It is expected that this proposed system will make a passed delivery date less probable. It is the writer's belief that the problem of control will not end here. More problems will come up as time goes on, among which will be problems of standardization in the industry, time study and scientific piece work rates.

KETCHAM TERRA COTTA COMPANY
CRUM LYNNE, PA.

HOW TO INSTALL AND OPERATE A FUEL OIL SYSTEM

By James D. Lalor

There are many sides to oil burning which a manufacturer never considers but I will confine my paper to the following:

1. How to install a fuel oil system to meet the requirements of the Board of Fire Underwriters so that you will obtain the lowest rate of insurance on your plant and insuring continuous operation.

2. The proper type of system to install to insure a good product with the lowest possible expenditure of power and fuel.

There are few men who know how to meet these requirements.

In laying out a fuel oil system, the first thing to do is to locate your tanks and pumps. These should be located in the lowest part of the property, so that if the containers break, there will not be the slightest possibility of the oil flowing to any part of your property or that of your neighbors.

The tanks should be placed (when possible) at least 6 feet below the lowest pipe in any of your buildings. The pump suction should be 3 feet higher than the top of the tanks, and the main oil line from the pump to the buildings should have a pitch of about $^1/_2$-inch in 10 feet to the point at which it enters the buildings, and where it enters the pipe should be at least 2 feet below the surface of the ground. All fuel oil lines will drain back automatically to the fuel tanks when the pumps are shut down and the system not in service.

The Rules of the National Board of Fire Underwriters state that all tanks shall be buried. I want to take exception here to that ruling. I say that fuel oil tanks should be put in concrete pits with sufficient room to walk around them, and if not in the building, to have a shed over them with open sides to protect them from the weather.

In the average plant, you will find more or less made ground or cinder fill. In spite of anything you can do, this will attack the iron in a short time. Then you will have leaky tanks, and your oil will seep away through the ground. In one instance of which I know, it found its way to the deep well from which the sprinkler tanks were filled. Upon examination of the sprinkler tanks, it was found that they had ten or fifteen thousand gallons of fuel oil in place of water. Therefore, leaving out the monetary loss, you are taking the chance of having it get into other parts of the property and causing considerable trouble. So put your tanks in a concrete pit where you can see them and examine them, and know exactly what is happening. In case of a fractured or a leaky tank, your oil can go into a pit and you can repair the tank at small cost.

All oil as it leaves the refinery contains more or less dirt, and when the oil leaves the tank car, it should run by gravity, or be pumped into an open strainer situated on the top of the tank (Fig. 1). The inside of the funnel should have a large removable basket strainer, which, when it becomes filled

with foreign matter, can be lifted out and dumped and put back into place without removing the body. In case heavy oils are used, it is a good plan to have a steam coil in the bottom of this strainer to warm the oil so that it will flow readily into the tank. When not in use, this strainer should be covered.

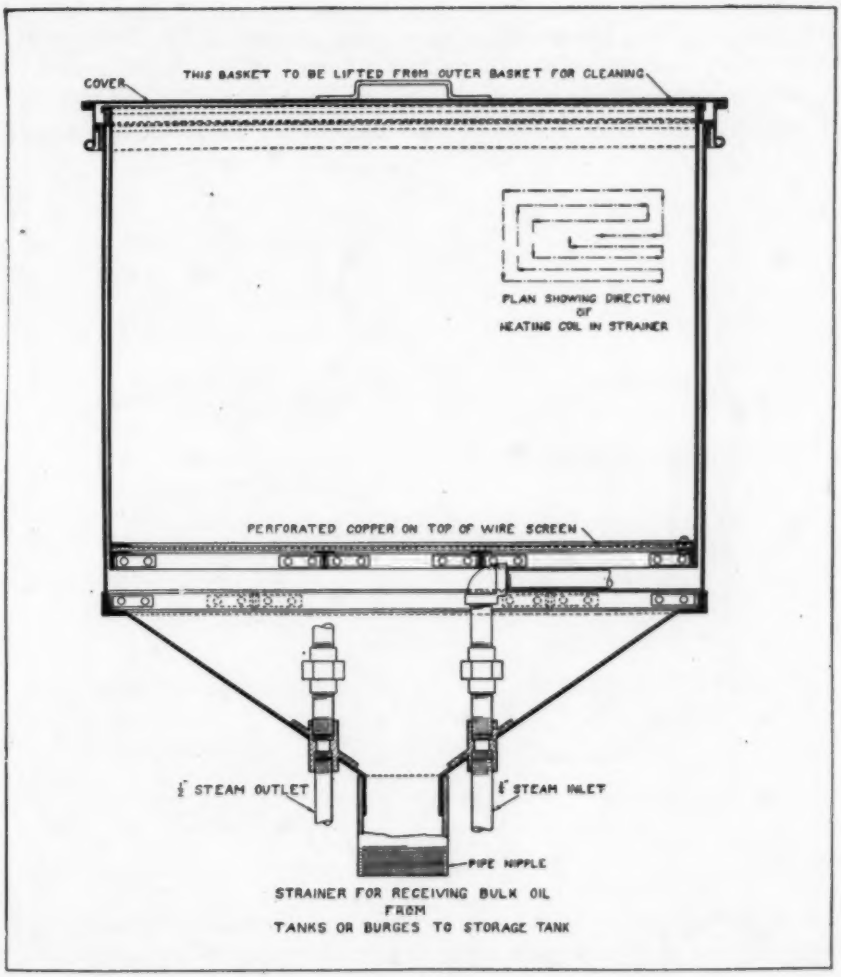

COVER
THIS BASKET TO BE LIFTED FROM OUTER BASKET FOR CLEANING
PLAN SHOWING DIRECTION OF HEATING COIL IN STRAINER
PERFORATED COPPER ON TOP OF WIRE SCREEN
1" STEAM OUTLET
1" STEAM INLET
PIPE NIPPLE
STRAINER FOR RECEIVING BULK OIL FROM TANKS OR BARGES TO STORAGE TANK

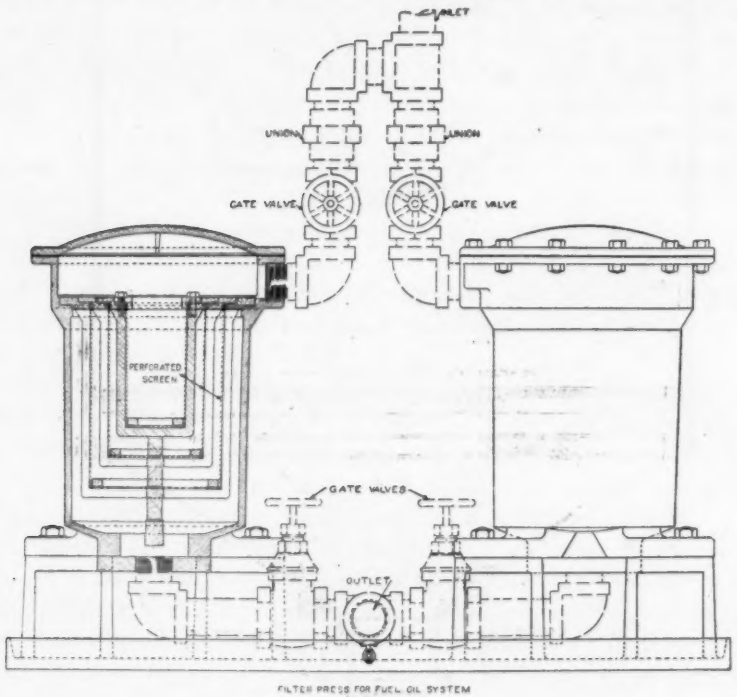
FIG. 1.

Many plants have a large filter press; the oil is received in tank No. 1 and pumped into tank No. 2 through the filter press, which removes anything that might possibly pass the large open strainer (Fig. 2).

All fuel oil tanks should be vented to permit escape of air when being filled. This vent pipe should be at least 3 feet higher than the highest

point of fill, which in the average plant would be at the top of the tank car.

Since the cold weather often affects the handling of fuel oil, it is very wise to put a heater in the tank (Fig. 3). There should be a sheet iron casing like a barrel, openings cut in the side to allow the fuel oil to flow in around the coil, a thermostatic control, so that the oil is never heated to more than 110°F. The oil will always pump readily at this temperature. As not more than the equivalent of 2 or 3 barrels of oil will be heated to this temperature, the amount of heat required is small. Twenty-five gallons an hour can be heated to this temperature on about one square



FILTER PRESS FOR FUEL OIL SYSTEM

FIG. 2.

foot of heating surface, with a pressure of about 5 pounds of steam. This eliminates the danger of gasification of the oil.

The suction to the pump should be made in one piece, passing through the top of the tank, no joints or connections being within the tank itself. This is done to eliminate the possible leakage of air into the suction line. The bottom of this pipe should be about 6 inches above the bottom of the tank, the end plugged and having perforations in the sides equal in area to the size of the pipe. This prevents possible lifting of any water that may collect in the tanks.

A fuel oil tank should be set 4 inches lower at one end, so that the water contained in the oil can settle to the lowest part and be pumped out from time to time as it may be found necessary. It is recommended that a half-inch pipe be run from the top of the tank to within one half-inch of the bottom and connected to a hand-pump outside the pit to remove this water. This line should always be at the opposite end of the tank from the main feed or pump suction. This prevents water getting into the

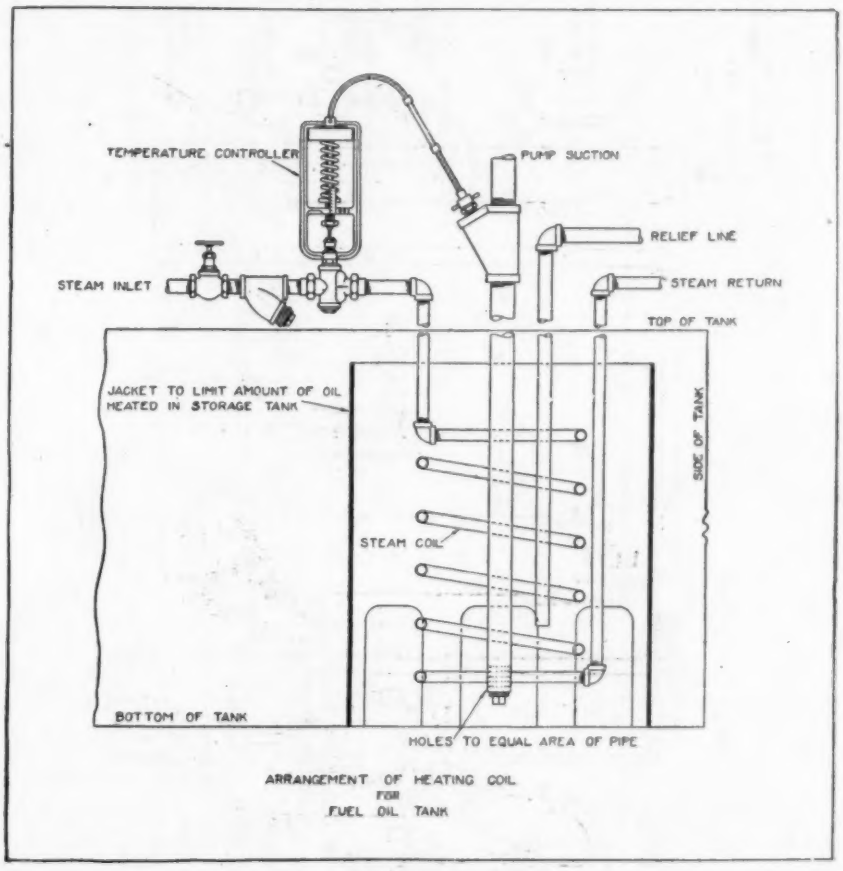


FIG. 3.

system causing sputtering and possible injury to the furnace or operator. Fuel oil, as a rule, will contain about ½ to 1% of water from a leaky steam line in the receiving tanks or in the tank car when the car is filled at the refinery.

The pumping system here shown is beyond all question the best adapted for fuel oil. The triplex pump prevents the flooding of a system in case of

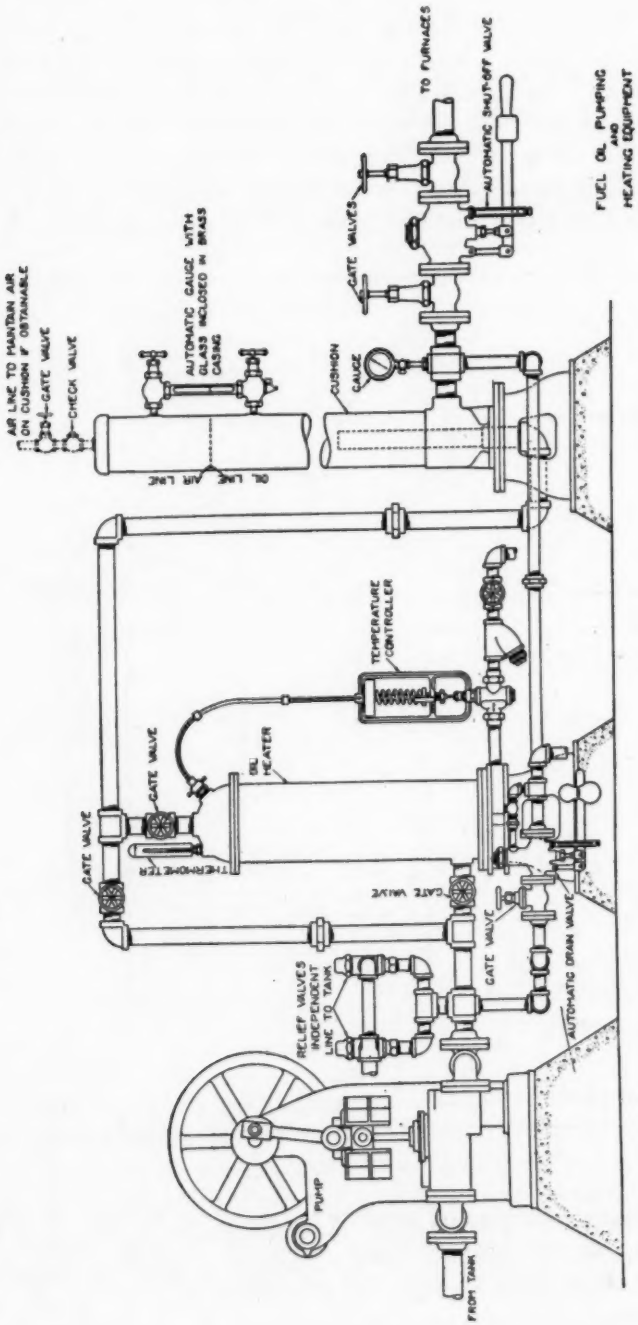
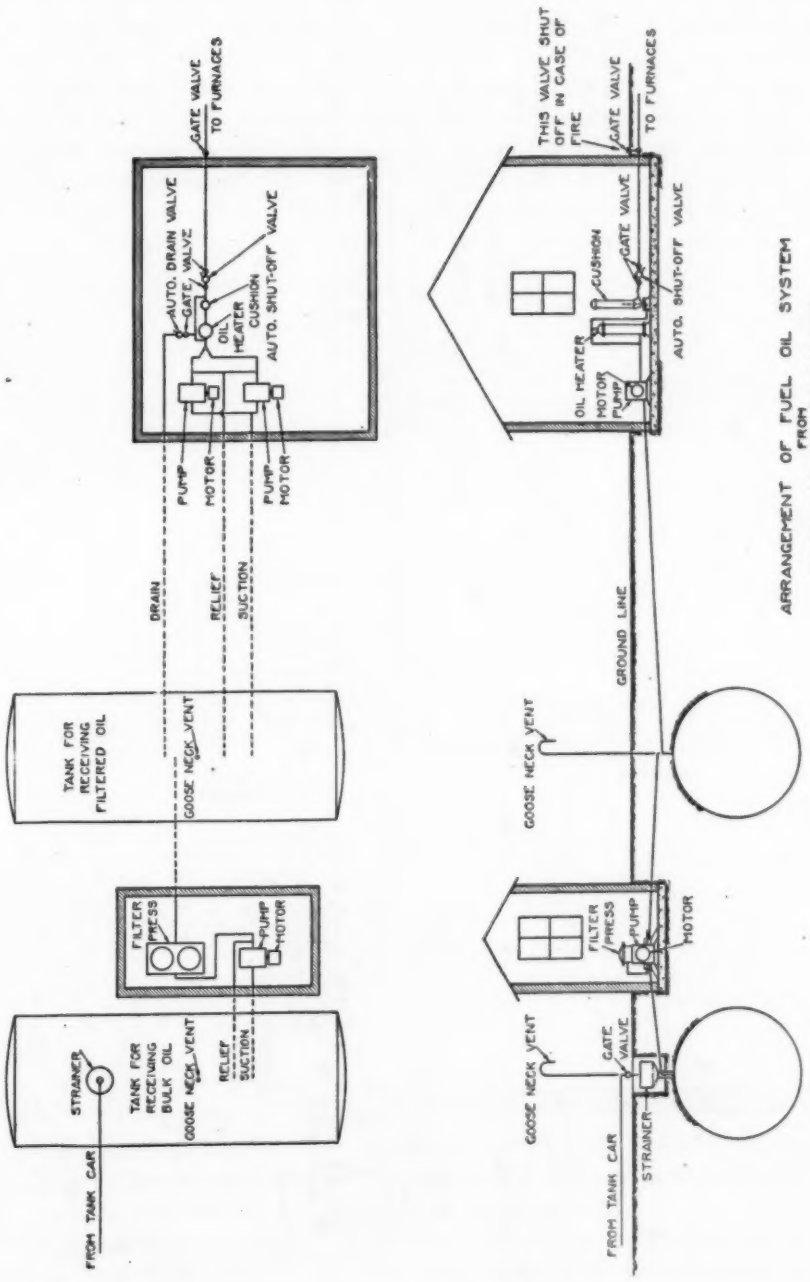
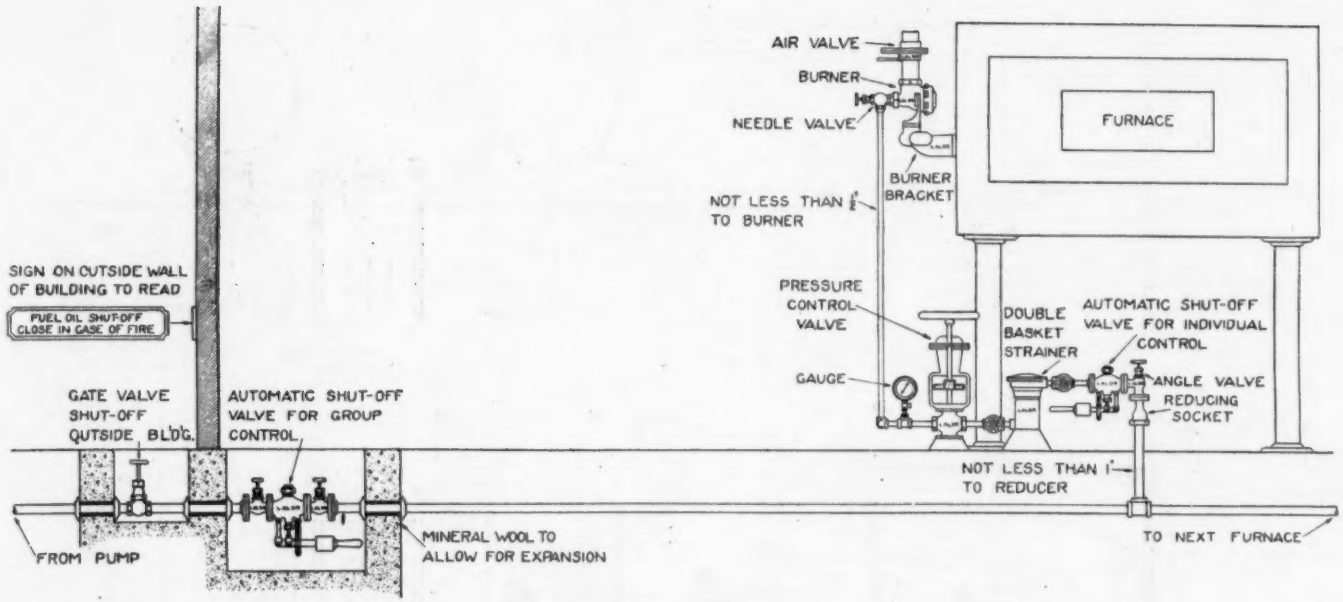

AIR LINE TO MAINTAIN AIR ON CUSHION IF OBTAINABLE
GATE VALVE
CHECK VALVE
AUTOMATIC GAUGE WITH GLASS INCLOSED IN BRASS CASING
OIL LINE
AIR LINE
CUSHION GAUGE
GATE VALVES
TO FURNACES
AUTOMATIC SHUT-OFF VALVE
FUEL OIL PUMPING AND HEATING EQUIPMENT
TEMPERATURE CONTROLLER
OIL HEATER
GATE VALVE
THERMOMETER
GATE VALVE
GATE VALVE
AUTOMATIC DRAIN VALVE
RELIEF VALVES INDEPENDENT LINE TO TANK
PUMP
FROM TANK

FIG. 4.



ARRANGEMENT OF FUEL OIL SYSTEM FROM TANK CAR TO FURNACES

FIG. 5.



METHOD OF INSTALLING
EQUIPMENT
FOR
FUEL OIL SYSTEM

Nº760

FIG. 6.

a broken line. The capacity of this pump should never be larger than twice the maximum oil consumption. There should be two pumps, and each pump should have two relief valves draining directly back to the tank. The heater should have a thermostatic control to prevent the oil from becoming warmer than within 25° of its flash point.

A cushion or accumulator maintains a steady pressure on the line and an automatic shut-off valve is advisable to insure against a loss in case of a ruptured oil line.

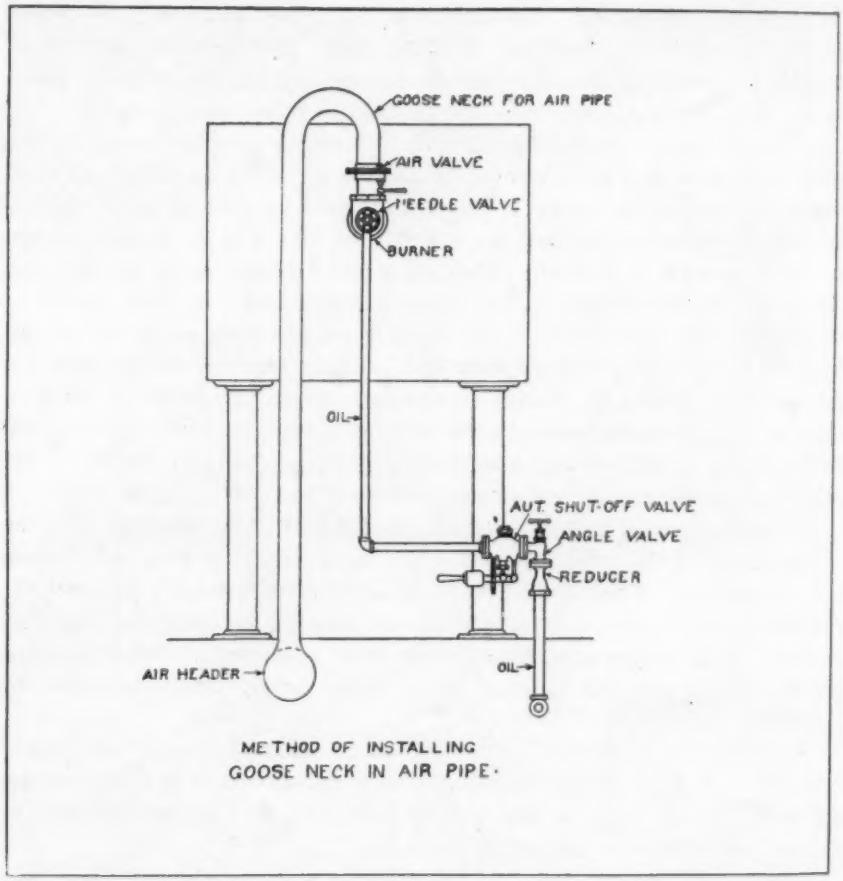


FIG. 7.

A drain valve is placed at the lowest point of the system and connected back to the fuel oil tank, so that the oil will drain automatically from the system when the pumps are shut down.

Figure 5 is a typical fuel oil system. There are two tanks in the ground, the receiving strainer, the vent, the filter press for clarifying the oil, the using tank, the pump, heater, cushion and accumulator, automatic

shut off and drain valves. All the lines pitch back to their source of supply so that they can be thoroughly drained.

Figure 9 shows how the lines should be laid out where there are a number of buildings in the plant.

Figure 6 is a typical plan of how an oil line should enter the building. The manual shut-off valve outside of the building in the pit has a plate over the valve, and a sign, "Fuel Oil Shut Off, Close in Case of Fire." This should be conspicuously displayed, with a red light over it at night when the plant is in operation. The ferrule in the wall is shown with the group control inside of the building; the lines under the floor; the method of tapping off the risers and carrying the lines to the furnace with the automatic shut-off valve protection, the air lines to come from overhead.

If the air lines are under the floor, they should be attached to the burner with a goose-neck (Fig. 7) coming up, so that no oil which should accidentally leak out of the burner could possibly pass into the air lines. If this should happen when the fans are started, the oil would be blown into the furnace, causing it to flash. The gas would explode in the air line, and probably set the building on fire. No oil piping under the floor should be less than 1 inch, and all risers should be of the same size until they extend to a point 12 inches above the floor line. This is required so that they will not easily be broken by moving equipment. From this point on, the lines can be $^1/_2$ inch to the burner, but no piping in any part of the system shall be less than $^1/_2$ inch in size, and this $^1/_2$-inch pipe shall run directly to the burner, and the burner connection shall be at least of the same size.

Those putting in fuel oil systems, should look very carefully into the construction of the relief valves of which there should be two, one of them for emergency. They should be constructed strong enough to stand the pressure which they control and should never have exposed adjusting screws. An oil-tight cap should cover these adjusting screws to prevent leakage, and also to protect them from being tampered with by employees.

Strainers are important. They should be made of bronze with copper screens, and all joints should be metal to metal, bolted or riveted, and not soldered, so that any foreign matter lodged in the perforations can be burned off without injury to the strainer.

Where strainers are used on high pressure systems, the cloth bag type will eliminate all fine particles of scale or sand from pipes, fittings and tanks. They should be of the double type, cross-connected, so that one can be cleaned while the other is in operation.

Oil strainers on a system are extremely dangerous if the strainer is not protected by an automatic shut-off valve, as the operators are liable to open the strainer while pressure is on the line, or may turn on the oil before a strainer is properly closed.

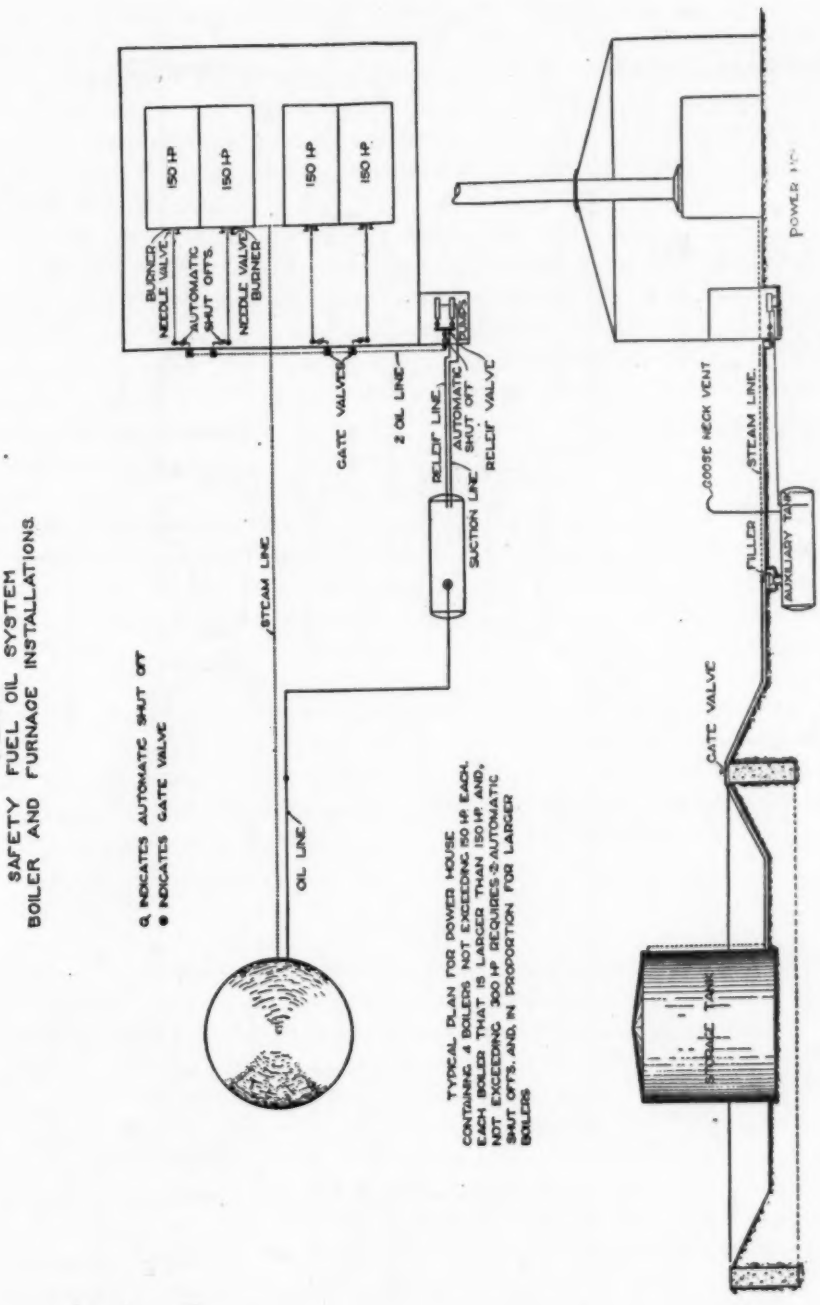
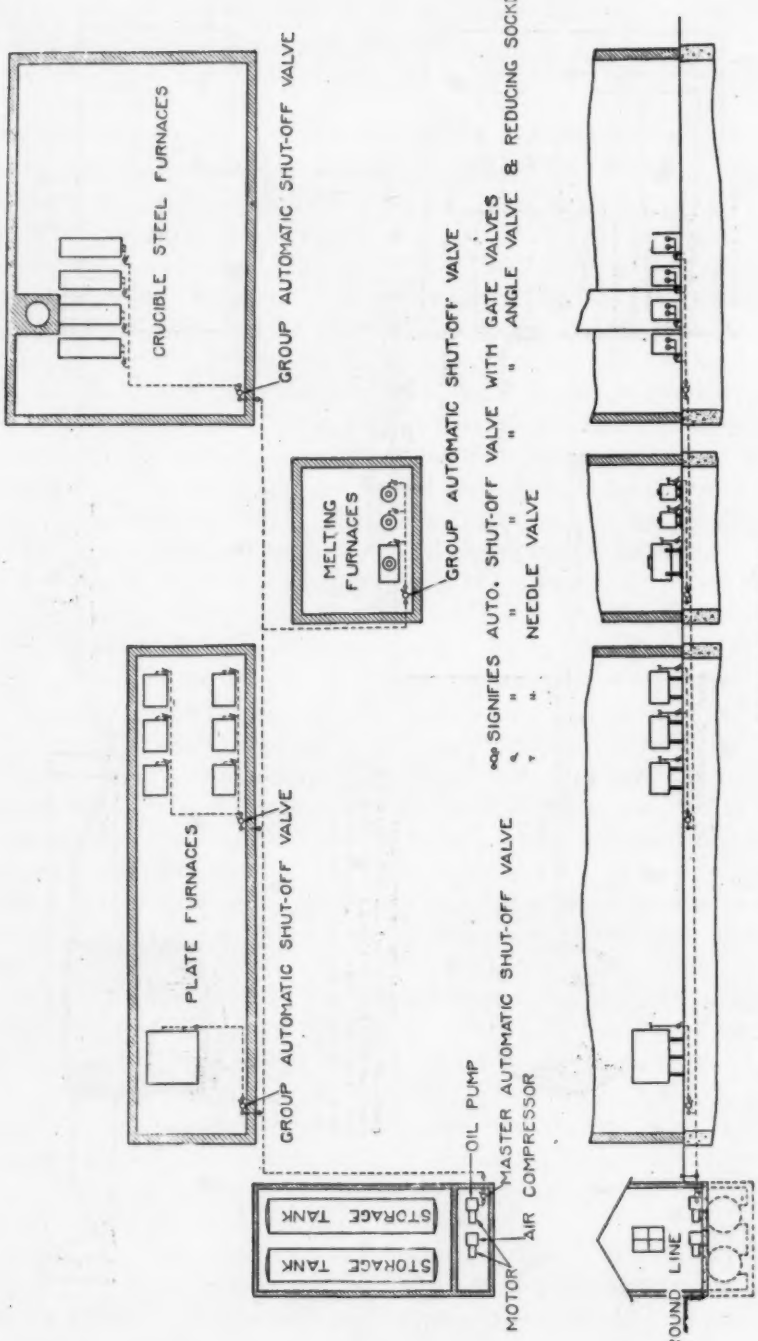

PLAN
SAFETY FUEL OIL SYSTEM
BOILER AND FURNACE INSTALLATIONS.
Q INDICATES AUTOMATIC SHUT OFF
● INDICATES GATE VALVE
TYPICAL PLAN FOR POWER HOUSE CONTAINING 4 BOILERS NOT EXCEEDING 150 HP. EACH. EACH BOILER THAT IS LARGER THAN 150 HP. AND, NOT EXCEEDING 300 HP. REQUIRES 2 AUTOMATIC SHUT OFFS, AND, IN PROPORTION FOR LARGER BOILERS
150 HP
150 HP
150 HP
150 HP
BURNER NEEDLE VALVE
AUTOMATIC SHUT OFFS.
NEEDLE VALVE BURNER
STEAM LINE
OIL LINE
GATE VALVES
2 OIL LINE
RELIEF LINE
AUTOMATIC SHUT OFF
SUCTION LINE
RELIEF VALVE
GOOSE NECK VENT
STEAM LINE
FILLER
AUXILIARY TANK
GATE VALVE
STORAGE TANK
POWER HO

FIG. 8.



PUMPING SYSTEM
FOR
FUEL OIL

FIG. 9.

In an installation of a fuel oil system, galvanized piping should never be used—only black iron piping, and it is advisable that extra heavy cast-iron fittings be used throughout the construction. All joints should be either sweated or put together with freshly mixed litharge and glycerine, and this composition of such an age that it will harden in 20 minutes when exposed to the air; any mixture exposed to the air more than 20 minutes should never be used.

Gravity, loop, or return systems should not be installed.

In regard to the cushion or accumulator used on a fuel oil system, it has been known to hydraulic engineers for a number of years that the only way to stop hammer blows in a water line is to put in a cushion or accumulator, so the water enters from the bottom and discharges at right angles to the flow and is cushioned by the air at the top. This effectively prevents the hammer blows which often break fittings. These accumulators can be home-made. They should be provided with automatic gauge cocks. It is known that oil will absorb air, and some means of supplying air to the accumulator should be provided. If the air in the plant is under a greater pressure than your oil pump is producing, the connection should be made at the top of this accumulator with a needle valve and check valve, so that no oil could possibly pass out of the accumulator and into the air lines in the plant. Once or twice a day the air should be replenished in the accumulator.

Many plants install special motor compressors for supplying this air, as here shown. It costs very little to operate these motors, as they will not operate more than 10 minutes a day, and the first cost is the only consideration. A steady pressure means efficient burning, and without it, this cannot be obtained.

LALOR FUEL SYSTEM COMPANY
BALTIMORE, MD.

Discussion[1]

BY C. J. HUDSON:—In reading over Mr. Lalor's paper "How to install and operate a fuel oil system" the predominant impression gained was that a fuel oil system is dangerous, intricate and something to be avoided if possible. During periods of coal shortage the thoughts of many people are turned toward fuel oil for a solution of the fuel question. Probably Mr. Lalor had in mind, when writing his paper, only helpful suggestions for the fuel oil user and he wished him rather to be fully aware of the precautions necessary for a successful installation than to discourage him with complexities. So it is hoped that a review of Mr. Lalor's paper, together with some of our own experiences, may be encouraging to one who is thinking of installing a fuel oil system.

The requirements of the Board of Fire Underwriters are simple and

[1] Received November 20, 1922.

effective. These can be readily obtained, together with the state laws, from local insurance companies. There is nothing about these laws which should deter one from making a fuel oil installation but they ought certainly to be known before the installation is started.

There are many concrete oil storage tanks in successful use. These are probably not subject to the kinds of corrosion that befall the iron tanks of Mr. Lalor's experience. At Norton Company an underground concrete tank of 100,000 gallons capacity has been in successful use for over two years. Where heavy oils are used there is little possibility of leakage.

Crude oil may contain a considerable amount of dirt. From the oil wells to the user, through the various distillation processes, this dirt has an opportunity to settle out every time it is allowed to remain in a tank. Therefore the amount of dirt which finally reaches the consumer should be small. An open strainer through which the oil must pass to enter the storage tank is a wise precaution, but the filter press suggested by Mr. Lalor seems an unnecessary piece of equipment. There should be strainers in the line to catch any sediment which might plug it. Our system contains three sets of strainers working satisfactorily. One set strains the oil on the suction side of the pumps, one set is on the oil line and the final set of finest mesh is at the burners. The strainers are not considered "extremely dangerous" in any way. They are not protected by automatic shut-off valves. We have not found any need for burning out these strainers. The usual custom is to wash them in kerosene oil twice a day.

Provision should be made for heating the oil. Most fuel oil cars are provided with heating coils. Heavy oils, 12 to 16° Baumé, must be heated in order to permit them to flow from the car in cold weather. Heating coils should be placed in the storage tank, around the intake pipe, and a steam line should parallel the oil line from the tank to the burners. The temperature to which the oil is heated just before entering the burners is quite important or at least it is necessary to maintain this temperature with small fluctuations. The reason for heating the oil is to lower the viscosity and thus facilitate atomization. If the oil temperature is fluctuating the flame will not be steady and will require frequent adjustment of oil and air (or steam) valves. Our system is provided with automatic temperature and pressure controllers. It is our belief that they should be installed on every oil system.

The cushion or accumulator recommended by Mr. Lalor is not a part of our equipment. We are not troubled with hammer blow and can see no use for such a piece of equipment except possibly in a system where very light oils are in use or where there is no return.

Mr. Lalor writes "Gravity loop or return systems should not be installed." Perhaps he meant to have left out the word "not," for by all means a return system should be installed. No return means that there must be a

dead end on the oil line. This means that the oil becomes stagnant at this dead end, so therefore becomes cold and the last burner on the line will not get the hot oil necessary for proper atomization. Another serious defect to a dead-end system is that an adjustment to one burner means a change on the other burners because the oil pressure on the line is thereby changed. This latter defect may be the reason why Mr. Lalor recommends accumulators.

Our oil system is installed on a Dressler tunnel kiln. A few difficulties have been experienced, but these must be expected with most any new equipment. When the causes of the difficulties were found, no time was lost in correcting them, so now we feel that fuel oil is an ideal source of heat, especially for a Dressler kiln.

The oil in use is asphaltic base of 14 to 16° Baumé, and about 19,500 B. t. u. per pound. Its viscosity is low. The oil is maintained at about 80 pounds pressure and atomized with air at 30 pounds. The oil temperature at the burners is maintained at 85°C. About twice as much oil is pumped through the system as is burned, the excess being allowed to return to the storage tank.

Water was at one time discovered in our storage tank. This was pumped out by means of an ordinary hand pump. The only other serious difficulty has been due to oils of high viscosity. The burners of our kiln are about 4 feet long and consist of an oil tube of small cross-section surrounded by suitable pipes for carrying air for atomization to the tip and water for cooling the burner throughout its length. With oils of low viscosity a pressure of 40 pounds will give satisfactory results, but a pressure of 100 pounds, the highest our system would stand, would not give a sufficient flow of the very viscous oil through burners of this type without shutting off our return. It is possible that a viscosity specification is not necessary for the short burners required on periodic kilns, but it is believed that if the less viscous oils can be obtained without difficulty it would be an advantage. The viscosity specification which we have found necessary for best results from our particular installation is that 200 cc. at 110°C shall take not more than two minutes to pass through a standard Engler viscosimeter. The gravity of a fuel oil and its viscosity are not related.

Our experience has taught us that fuel oil is an ideal source of heat if its temperature and pressure are kept constant. These two controls are indispensable, but fortunately it is easy to maintain them constant by means of automatic instruments now on the market for these purposes.

NORTON COMPANY
WORCESTER, MASS.

FUEL OIL AS APPLIED TO PERIODIC UP-DRAFT KILNS IN THE MANUFACTURE OF HIGH TENSION ELECTRICAL PORCELAIN

By L. H. Brown

The following paper is not intended to serve as a complete list of last word procedure to be followed by prospective users of fuel oil, but may serve as a slight assistance to someone who, under similar circumstances, is compelled to make a complete change of burning equipment in a comparatively short time, as was necessary at the plant of the R. Thomas and Sons Co., East Liverpool, Ohio, during the late fall of 1920.

Business conditions at that time were of such a nature as to preclude any possibility of an exhaustive experimental study of the subject, and the question resolved itself into one of obtaining *something* to burn, and not of efficiency. The general layout of the plant does not lend itself readily to the use of coal—in fact, but three of the twelve kilns could be fired advantageously with coal.

The initial storage equipment consisted of an immense concrete tank buried completely below the level of the railroad spur. The tank was divided into two compartments of a combined capacity of 125,000 gallons. The bottoms of both compartments were sloped sufficiently to allow sediment and water to be drained off through drain cocks at will, and ventilators of 3-inch pipe were carried above the level of the adjoining buildings to carry off the volatile constituents which might rise in the event that the oil be overheated by the preheater. No protective coating of any kind was used on the inside of the tank

The preheater consisted of a coil of $1^1/_2''$ pipe, and was 3 feet square and 4 feet high, located at the end of the intake pipe about 4 inches from the bottom at the shallow end of each tank. A T-connection from the pump with two valves enabled them to draw from either compartment at will. Steam at 80-pounds pressure could be used whenever desired, but it was never necessary, either in the winter of 1920 or 1921, to use steam at all in this tank when 24–26 Bé oil was used. It must be borne in mind that this tank was utilized merely as a storage reservoir.

A Weinman cylinder pump, manufactured at Columbus, Ohio, forces the oil from the storage tank to the operating tank in the plant proper at a 30-foot higher elevation. This pump (2″ diameter by 4″ stroke) operates successfully with a direct connected one-horsepower motor (Fairbanks-Morse) and delivers about an average of 15 gallons per minute. By-pass connections and valves permit of complete draining of the supply line after the pump is shut down. This pump is located on the top of the tank.

Oil for the kilns is pumped from the operating tank, which is located within the main plant and buried beneath the floor level. This tank is also of concrete and is of 6,000-gallon capacity. It was likewise provided with sloped bottom and drain cocks for the removal of water and sediment.

No piping whatsoever was submerged in it, except the pump intake, as the preheating was accomplished by a separate unit.

The pump supplying the kilns is a remarkably efficient and reliable outfit with an upkeep cost of practically nothing and a low power cost. It is handled by the Schirmer Company of Cleveland, Ohio, is known as the Viking Pump, and operates on the centrifugal principle, delivering oil without the pulsation so often contended with in some cylinder pump installations. Pump and motor ($^1/_2$ h. p.) are direct connected, and it is almost unbelievable that so small an apparatus can operate so continuously and efficiently. It has been known to build up a pressure of 80 pounds when the steam supply failed and the resulting increased viscosity of the oil brought about greater resistance. A maximum delivery of 10 gallons per minute is guaranteed on this particular size of pump.

Strainers connected in parallel remove coarse material from the oil after leaving the pump. Oil passing through these strainers enters the preheater at the bottom, rises through coils surrounded by steam (80 lb.) in the jacket, and emerges at the top where its temperature and pressure are shown by appropriate gauges.

Steam in the jacket enters at the top and the condensate passes out through a trap at the bottom. The National Supply Company of Chicago, Ill., furnish preheaters of this type.

The entire capacity of the pumps is scarcely ever used, therefore an adjustable by-pass arrangement was introduced at the point where the hot oil emerged from the preheater. Some excess oil was diverted back to the tank at this point, and gradually raised the temperature of the supply, the maximum temperature being controlled by a thermostat. Depth gauges operating on the inverted bell principle do not indicate properly on a tank installation of this kind, unless equipped with temperature variation compensators.

No piping smaller than 1-inch was used on any part of the installation except at the burner connections where $^3/_4$-inch pipe was used. After this system had been in operation several months it was noticed that material was depositing on the pipe wall to a considerable thickness and would occasionally loosen, pass along and clog the burners. It is a question whether the use of smaller pipe with a resulting higher velocity would decrease the tendency to deposit.

All oil connections were made upward to the burners, to safeguard against leakage of oil into the air ducts.

The burner equipment consisted of Leader-Furnace Equipment and Maxon-Premix Burners, both types being designed for the use of gas and oil. The change from one fuel to the other can be made within a few moments without interfering with the firing. A fire-brick wall was laid at the front of the ash pit, allowing three half-brick air passages in the first

course and a 4″ x 4″ opening 6 inches from the bottom, for the burner. The burner tip is at least 36 inches from the ends of the radial flues.

Several different types of combustion chambers were tried, but with little success, as most of them tended to restrict the heat in the fire-box with a rapid deterioration of fire brick as a result.

One kiln installation was made using carborundum brick at the ends of the radial flues but corundite brick were later found to be just as satisfactory and considerably cheaper. When properly laid, that is, with a dip joint, very little trouble is encountered.

The air is supplied to the Leader-Furnace Equipment Co. burners by a Spencer Turbo-Compressor direct connected to a (10 h. p.) motor. A five-ounce pressure is sufficient for normal conditions although the fan has a considerably higher rating. The air ducts are uniformly 8-inch diameter, galvanized sheet with the exception of the kiln and burner pipes, which are slightly smaller. Butterfly dampers are placed at every kiln connection and serve as another point of control.

Air for combustion in the Maxon Equipment is supplied by a Maxon Premix rotary blower, 18 inches in diameter, and driven by a (3 h. p.) motor. This equipment furnishes the air supply for two kilns equipped with the latest Maxon burners. It delivers the air at a maximum pressure of three ounces to the sixteen fire-boxes.

Both types of burners are supplied simultaneously by the same oil pump but a higher oil pressure is required for atomization in the Maxon burners than in the other type. It has been found that atomization is more complete with pressures between 30 and 40 pounds when the Maxon is being supplied, but scarcely more than 15 pounds pressure is required with the Spencer burners. This, however, is not a disadvantage in this particular installation as the higher pressure can be carried whenever those particular kilns are under fire.

The following figures are only approximate but may give an idea of the comparative cost of firing a 16′ 0″ diameter kiln, 14′ 2″ to the shoulder. This size of kiln is never fired in less than 72 hours for economy in firing time usually results in incompletely vitrified ware. When fired with Pittsburgh coal using removable grates, such a kiln usually requires 12 to 13 tons of coal and will ordinarily consume 225,000 cu. ft. of natural gas when equipped with the old fashioned gas burner. With the present equipment a consumption of 2200 gallons of 24°–26° Bé. refinery residue oil gives very good results.

An examination of results over a long period of time shows clearly that oil firing is a decided success and profitable. There are, however, difficulties which will be overcome as the user becomes more familiar with it. Some of these difficulties can be cited briefly.

The stoppage of oil supply lines from the pump can be cleared up in a

very short time by disconnecting the intake from the tank and circulating common kerosene oil through the lines for a short time and draining out. Some users even go to the extent of using a small amount of kerosene with the fuel oil, thus preventing a complete shutdown while the deposit is being removed.

Water accumulation in fuel oil storage tanks, coming from tank cars, will occasionally cause considerable trouble especially when a rotary pump is used. If the water level rises high enough it will be drawn through the pump where a water-oil emulsion is formed, which is almost impossible to burn. It spits and frys in the kiln fire-box, sometimes refusing to burn, and results in loss of time and temperature. When such a condition is encountered the oil should be pre-heated to about 220°F if its flash point will permit and the moisture driven off through a large temporary ventilator. However, such a circumstance need never arise if an occasional inspection is made of the settlings leaving the drain cocks.

Exceedingly erratic results are occasionally obtained when an inexperienced fireman first uses oil. The great tendency is to produce reducing conditions within the kiln, resulting in bloated pyrometric cones, black coring and a deposition of carbon in the kiln mouth, which must be continually broken off to prevent flashing back. The carbon deposit builds horizontally from the back of the kiln mouth toward the burner in the form of a cylinder. The atomized fuel striking this is diverted toward the arch and kiln door, heating these red hot. With proper care in the regulation of the mixture of oil and air, and with adequate combustion space these conditions are minimized.

Radiation losses are very much greater when the kilns are fired under slight pressures. While this may seem to be a rather inefficient condition, the results seem to show that much better heat distribution is obtained. With an improvement in quality of kiln lining refractories backed up with insulating material, the radiation loss should be no greater than when the old style gas burners or coal were used.

A vital mistake is made by applying oil burners to kilns whose fireboxes were originally intended for gas or coal without proper changes. The combustion space must necessarily be much larger when burning concentrated fuels and more space should be allowed for the heat to pass into the kiln over the bags and through the radial flues.

Oil-fired kilns of this type require more frequent attention from the fireman due to the intensity of the oil flame, and its effect on the deformation of the pyrometric cones.

EDWIN M. KNOWLES CHINA COMPANY
EAST LIVERPOOL, OHIO

A STUDY OF THE SLAG TEST

By R. M. Howe

ABSTRACT

Several methods of making slag tests are discussed. A large amount of experimental data pertaining to the "penetration" test are presented. They show that there is no relationship between the results obtained in the plant and in the laboratory. A newer method of testing appears to give more satisfactory results. This is based upon the depression of the melting points of refractories by the addition of slags.

Introduction

By 1917 two important methods for studying the action of slag upon refractory materials had been developed in this country, one at the U. S. Bureau of Standards and the other at the laboratory of the Carnegie Steel Company. Since that time this action has been studied intermittently at the Mellon Institute of Industrial Research and the results have been summarized in the following paper.

The method employed at the U. S. Bureau of Standards was as follows:[1]

> Fire-clay boxes, whose inside dimensions were 9 inches in length, 8 inches in width, and 3 inches in depth, were molded from a finely ground refractory mixture and burned to cone 12. Each brick to be tested was placed on edge in the box and firmly packed with the finely ground slag on the two sides. In the first series of tests, slag prepared from the ash of the coal was used. In the later tests the brick were subjected to the action of a synthetic mixture having a composition approaching that of the slag.
>
> Twelve of the boxes were placed in a down-draft kiln fired with natural gas. The temperature was increased to 1400°C, over a period of 36 hours. For this slag, reducing conditions were maintained in the kiln over the last 12 hours of the burning. . . . . In order to observe the corrosive action and penetration of the slag, each box that contained brick was broken into two or three parts.

The advantages claimed for the method are:

1. A large portion of the brick is subjected to the action of the slag.
2. A large quantity of slag is used, thus preventing appreciable changes in its chemical and physical properties as action progresses.
3. The time effect may be studied.

The main details of the method developed at the laboratory of the Carnegie Steel Company were as follows:[2]

1. Drill two standard sized cavities in each of three or more brick.
2. Select a suitable slag and grind to 40-mesh size.
3. Heat the test brick to 1350°C in not less than 5 hours, introduce 35 grams of slag to each cavity, and allow it to react at that temperature for 2 hours.
4. Saw the cooled brick so that each cavity is bisected and measure the area penetrated by the slag. This penetration is used as a means of expressing the relative resistance of each brick to the action of that particular slag.

[1] G. H. Brown, "A Method of Studying the Corrosive Action of Slag on Firebrick." *Trans. Amer. Ceram. Soc.*, **18**, 277 (1916).

[2] *Proc. Amer. Soc. Testing Materials*, **17**, 669 (1917).

This was adopted as a tentative method by the American Society for Testing Materials in 1917. The writer then began a systematic study of the method from a laboratory standpoint and at a later date was able to compare test results with those obtained under service conditions. Seven samples of slag[1] and three brands of fire brick were used in making the first tests. The analyses of the slags are given in Table I.

TABLE I

ANALYSES AND MELTING POINTS OF SLAGS

	Blast furnace	Heating furnace	Basic open hearth	Acid open hearth	Coal ash	Zinc	Copper
Silica	37.72	34.16	18.42	46.48	54.86	34.30	28.20
Alumina	13.21	6.13	3.85	5.45	30.50	14.74	2.20
Iron Oxide	1.62	43.60	14.55	29.30	7.20	21.00	2.10
Lime	42.20	1.30	44.10	2.16	.00	2.33	2.51
Magnesia	2.35	.65	6.32	.00	2.01	7.07	2.14
Manganese	1.11	.55	5.09	9.08	.09	6.77	.00
Sulphur	1.20	.27	.42	.38	.38	5.88	.14
Phosphorus	.00	.02	.58	.00	.01	.02	.24
Copper	.00	.00	.00	.00	.00	1.28	58.21
Zinc	.00	.00	.00	.00	.00	8.20	.00
Melting Point—°C.	1220	1050	1275	1400	1130	1025	1020

The fire brick, A, B, and C, were typical first-quality products of the New Jersey, Kentucky and Pennsylvania districts.

Influence of Time

Among the first tests were those in which samples of fire brick C were subjected to the action of 35 grams of slag at 1350°C for 2-, 4-, and 6-hour periods. The penetrations were .64, .68, and .64 inches, respectively. It was evident, therefore, that the penetrations observed in these tests were practically complete in less than two hours. In this respect the results differed from those obtained in service, where the action of slag is progressive and very largely dependent upon the time factor.

Influence of Quantity

In the next tests the samples were subjected to the action of 35 and 105 grams of slag for 2 hours at 1350°C. The penetrations were .64 and .76 inches, respectively. Thus, an increase of 200% in the severity of the test resulted in 19% greater penetration.

Influence of Time and Quantity

Further tests were made in which both the time of reaction and the quantity of slag were increased. The results are given in Table II.

[1] By courtesy of J. S. Unger, Central Research Bureau, Carnegie Steel Company, Pittsburgh, Pa.

TABLE II
INFLUENCE OF TIME AND QUANTITY OF SLAG UPON PENETRATION

	2 hours	4 hours
35 grams	.64 in.	.68 in.
105 grams	.76 in.	.72 in.

In this case the severity of the test was increased from 100 to 500%, yet the observed penetration showed a maximum increase of only 19%. As a matter of fact this variation in the results is within the possible experimental error.

Influence of Furnace Atmosphere

It is a well-known fact that the melting points of slags show considerable variation, depending to a very large extent upon the furnace atmosphere in which they are heated. One coal ash was reported, for example, as melting at 1086°–1119°C under reducing conditions and at 1279°–1305°C under oxidizing conditions. A slag of this nature might give far different results in the slag test if the furnace atmosphere varied, for the activity of a slag at a given temperature would be affected by the same factors that influence its melting point.

Several tests were made in which a highly oxidizing or highly reducing atmosphere was maintained in the furnace. They were conducted for two hours at each of four temperatures. Copper and heating furnace slags were used because of the fact that they contain 58.2 and 43.6% of copper and iron, respectively. The copper slag melted at 1020°–1090°C according to the furnace atmosphere, while the heating furnace slag melted at 1050°–1350°C. The penetrations obtained under the various conditions are recorded in Tables III and IV.

TABLE III
SLAG PENETRATIONS OF BRICK A UNDER DIFFERENT FURNACE CONDITIONS

	Copper Slag			Heating Furnace Slag	
Temperature	Oxidizing	Reducing	Temperature	Oxidizing	Reducing
1150°C	.46 in.	...	1150°C	.04 in.	.48 in.
1250°C	.65 in.	.17 in.	1250°C	.09 in.	...
1350°C	.35 in.	.30 in.	1350°C	.15 in.	...
1450°C	.39 in.	.26 in.	1450°C	.34 in.	.90 in.

TABLE IV
SLAG PENETRATION OF BRICK C UNDER DIFFERENT FURNACE CONDITIONS

	Copper Slag			Heating Furnace Slag	
Temperature	Oxidizing	Reducing	Temperature	Oxidizing	Reducing
1150°C	.52 in.	...	1150°C	.07 in.	.68 in.
1250°C	.62 in.	.45 in.	1250°C	.10 in.	...
1350°C	.83 in.	.45 in.	1350°C	.24 in.	...
1450°C	.46 in.	.30 in.	1450°C	.78 in.	.94 in.

Thus, it was demonstrated that the results of the slag test depend to a very great extent upon the atmosphere of the furnace. In the case of the

copper slag, metallic copper actually separated out under reducing conditions and in that way lowered the active constituent of the slag. The heating furnace slag was more active under reducing conditions because of the greater activity of the ferrous compounds as compared with those containing ferric iron. The furnace atmosphere should, therefore, be carefully controlled if comparative results are to be obtained with slags of this type.

Effect of Furnace Temperature

The effect of varying the furnace temperature was next studied for it seemed as if greater flexibility should be allowed in this feature of the test. Inasmuch as certain slags are heated to much higher temperatures than others in service, it would be logical to follow the same practice in making the tests. While 1350°C might be ideal for certain slags and furnaces, a higher or lower temperature would be more satisfactory for others.

Three brands of fire brick were subjected to the action of seven slags at 1150, 1250, 1350 and 1450°C. The slags were heated for two hours under oxidizing conditions. The results are given in Tables V, VI, and VII.

TABLE V

PENETRATION OF DIFFERENT SLAGS ON FIRE BRICK A

Slag	Blast furnace	Heating furnace	Basic open hearth	Acid open hearth	Coal ash	Zinc	Copper
1150°C	...	.04	...	...	.01	.03	.46
1250°C	.03	.09	...	...	.01	.13	.65
1350°C	.08	.15	.58	...	.03	.28	.35
1450°C	.14	.34	.73	.24	.02	.19	.39
Melting pt. of slag	1220°C	1050°C	1275°C	1400°C	1130°C	1025°C	1020°C

TABLE VI

PENETRATION OF DIFFERENT SLAGS ON FIRE BRICK B

Slag	Blast furnace	Heating furnace	Basic open hearth	Acid open hearth	Coal ash	Zinc	Copper
1150°C	...	.02	...	...	.01	.04	.36
1250°C	.00	.05	...	...	.02	.16	.57
1350°C	.11	.11	.29	...	.03	.29	.39
1450°C	.17	.79	.33	.33	.02	.32	.34
Melting pt. of slag	1220°C	1050°C	1275°C	1400°C	1130°C	1025°C	1020°C

TABLE VII

PENETRATION OF DIFFERENT SLAGS ON FIRE BRICK C

Slag	Blast furnace	Heating furnace	Basic open hearth	Acid open hearth	Coal ash	Zinc	Copper
1150°C	...	.07	...	...	.01	.05	.52
1250°C	.07	.10	...	...	.02	.24	.62
1350°C	.12	.24	.44	...	.01	.33	.83
1450°C	.17	.78	.55	.57	.02	.43	.46
Melting pt. of slag	1220°C	1050°C	1275°C	1400°C	1130°C	1025°C	1020°C

These data show that the penetration at different temperatures are not in the same ratio. Consequently, the results at any single temperature cannot be accepted as being typical. In order to secure a comparison between different fire brick it is at least necessary, therefore, to test them at a temperature approximating that of the industrial furnace in which the slags are melted.

In making this study a far more serious criticism of the test was discovered, however. It became evident that no distinction was made between mechanical penetration and chemical action when the results were reported in terms of penetration. The lack of this distinction and its practical importance was particularly noticeable in the results obtained with the copper slag. These have been recapitulated in Table VIII.

TABLE VIII

PENETRATIONS OF COPPER SLAG AT FOUR TEMPERATURES

Brick	1150°C	1250°C	1350°C	1450°C
A.....	.46 in.	.65 in.	.35 in.	.39 in.
B.....	.36 in.	.57 in.	.39 in.	.34 in.
C.....	.52 in.	.62 in.	.83 in.	.46 in.

At 1150° and 1250°C the results indicate the extent to which the slag had seeped into the brick, filling the pore spaces, but not taking the clay into solution. The action was practically the same as when water penetrates a concrete pillar, there being no loss in mechanical strength due to this penetration. At 1450°C the action was entirely different for the slag completely dissolved the brick as it penetrated, decreasing its value proportionately. These facts are not brought out in Table VIII, and one might infer that the behavior of brick C was better at 1450°C than at 1250°C. As a matter of fact, the penetration of .62 in. at 1250°C was not in the least serious, whereas the penetration of .46 in. at 1450°C represented failure.

A similar condition can arise very easily when fire brick of different types are being tested at any one temperature. Those which are open and porous will always show a large penetration, although they may be unaffected by the solvent action of the slag. On the other hand, very dense brick may show a low penetration, although they are seriously attacked.

After having conducted this extensive laboratory investigation of the slag test, there was considerable doubt in the writer's mind as to its practical value. Nevertheless, two attempts were made to reconcile the results obtained with those obtained in service.

The first attempt was made in a checker-work where the brick were rapidly cut away by the corrosive action of slag. Three brands were selected for a competitive test and the results follow:

Type	Grind	Process	Fusion point	Slag penetration	Service
1.....	Fine	Steam-press	Cone 31½	.29 in.	Fair
2.....	Medium	Hand	Cone 32½	.52 in.	Good
3.....	Medium	Steam-press	Cone 32½	.00 in.	Good

It can be seen that there is no relationship between the results of the slag test and the service obtained, although the brick failed in each case because of slag action. The writer concluded that inasmuch as the same raw material was used in making bricks 2 and 3, it was more resistant to the action of slag than that which was used in those of type 1. Being resistant to this action, the question of density was of little importance in service for the steam-pressed (3) and hand-made brick (2) gave practically the same results. On the other hand, the denser steam-pressed product (3) gave far better results in the laboratory.

At a later date two brands of fire brick of the following characteristics were subjected to a competitive test in a cupola:

	A	B
Burn	Hard	Medium hard
Grind	Fine	Coarse
Fusion Point	Cone 29 to 31	Cone 31
Penetration of Slag in Laboratory Test	3.58 sq. in.	5.35 sq. in.
Chemical Analysis		
Silica	52.70	57.84
Alumina	38.17	34.14
Ferric Oxide	6.30	2.75
Lime	.18	.30
Magnesia	.13	.58
Alkalies	.93	1.59
Titania	1.89	2.75
Total	100.30	99.95

Standard 4″ x 6″ blocks were laid up in each half of a Whiting cupola so that they received identical treatment. They were first dipped in a thin fire-clay slip, were then hammered into place, and finally covered with additional slip.

The furnace was running on new pig and clean scrap, using Syracuse limestone as a flux. Sixty-five to sixty-eight ton heats were taken off in three hours. After 48 hours 4 inches of the "A" blocks had been eaten away, while only 1 inch of the "B" blocks had been affected.

Three striking contrasts were noted between the practical and test results:

1. In practice, the slag never penetrated more than .25 of an inch while in the test the depth of penetration was .5, 2.0, 2.0 and 3.5 inches.
2. In practice, the penetration was uniform; in the test it was not.
3. In practice, the "B" blocks gave four times the service; in the test, the "A" blocks were better by 50 per cent (ratio = 3.58 : 5.35).

These results convinced the writer that there was no relationship between the results of this slag test and the action of slag in service.

Another method, based on entirely different principles, had been advocated for some time, but had never been investigated in this laboratory. The lack of investigation was due to unfavorable reports received in 1917. Favorable reports were received later and it was decided to apply the method in testing the cupola blocks previously described.[1]

Samples of each block were ground to pass 60-mesh and were then mixed with different percentages of slag. These mixtures were made into cones and their fusion points determined. In making these determinations it was assumed that all fire brick are ultimately penetrated by slag. This being the case mixtures of fire brick and slag are formed on the inside of the furnace. If these mixtures are of high melting point they will be less affected at a given temperature than those of lower refractoriness. Consequently, the relative fusion points of several brick slag mixtures should indicate the resistance of those brick to the action of that slag.

The fusion points of the A and B brick and slag mixtures are given in Table IX.

TABLE IX

Per cent slag	Fusion points of A and B brick with Slag No. 1		Fusion points of A and B brick with Slag No. 2	
	A	B	A	B
4	20–26	27–28	17–18	26–27
8	19	20–26	16–17	20
12	15–16	18	14	14–15

It is evident from these results that the linings of type A were less resistant than those of type B to the chemical action of the slags. On the other hand, those of type A were more resistant to penetration, as was shown by the slag tests. In view of the service obtained from the two blocks in this particular case one would conclude that resistance to chemical action was of more importance than resistance to penetration. At least the test which is based upon the solvent action of the slag gave results in agreement with those obtained in service, while the test which measured penetration did not. Since the claims made for the practical value of the fusion point method of making slag tests were justified in this case, plans were made for further investigation, the results of which will be reported at a later date.

Summary

Two distinct types of slag tests have been studied in this laboratory. In one case the penetration of the slag is measured by means of a planimeter; in the other its solvent action is determined by studying its effect upon the fusion points of fire brick.

[1] H. D. Fischer, "Looking for a Brick," *Combustion*, February, 1919.

Eight points were developed in the study of the penetration test. The results of the test are not influenced to an appreciable extent by increasing the time of the test or the amount of slag. They are affected by the furnace atmosphere. Generally speaking penetration increases with an increase in temperature, although the increase with different slags and brick are not relatively the same. The results are controlled to a very large extent by the density of the brick, being low with the steam-pressed product and high with the hand-made. The results also appear to be lower with the finer grinds. It was impossible to discover any relationship between the laboratory and practical results. A very serious weakness of the test was found in the method of reporting, it being impossible to describe the action of the slag by simply recording the penetration.

The other test was not studied in great detail, but the results to date are very encouraging.

Discussion

In most cases the surface of the brickwork in contact with the slag is much hotter than the inner portions. Consequently, as the slag penetrates a short distance it becomes more viscous at the lower temperature of the interior of the brick and finally solidifies. Further penetration is impossible until the temperature equilibrium is disturbed. This is not destroyed until the diameter of the hearth is increased by the solvent action of the slag upon the refractory brick.

Slag action is, therefore, divided into two parts—penetration and solution. Penetration, however, is not necessarily important, for the penetrating slag may have no solvent effect whatsoever upon the brickwork. In any event, the action of the penetrating slag will always be less severe than that of the hotter, more concentrated slag at the surface. Furthermore, penetration will always cease as the cooler portions of the brick work are reached.

On the other hand, the solvent action of the slag upon the fire brick is extremely important, for as it progresses new portions are exposed and complete destruction finally results. It is dependent only to a very slight extent upon penetration, for, as has already been stated, the greatest solvent takes place at the hotter surface.

It is not surprising, therefore, that a slag "penetration" test is of slight practical value, for its results may be obscured by a high or low resistance to solvent action. On the other hand, a test designed to show resistance to chemical action should give information of practical value. Present information indicates that the fusion point method measures solvent action and, therefore, supplies an urgent need. This method is now being studied in detail and the results will be reported at an early date.

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[1] The abbreviation (*C. A.*) at the end of an abstract indicates that the abstract was secured from the Editor of *Chemical Abstracts* by coöperative agreement.

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General and Miscellaneous

1. Coal saving methods in brickworks. ANON. *Brit. Clayworker*, **30**, 281(1922).—The power plant is usually one of the most inefficient sections of the works. Coal should be dumped into suitable bins near the fireholes, care being taken not to waste it. Coal loses heating power by being stored in the open. It may be moved most economically by means of continuous bucket or scraper and steel link conveyors. The best way to store coal is in bins separated by means of triangular sections of corrugated iron. Considerable coal is lost in the ashes due to poor stoking and firing with too thick a bed of coal. To det. if coal is present in the ashes, put the ashes in a pan of water and stir thoroughly. If coal is present it will float. A CO_2 recorder is a good investment since the percentage of CO_2 should be high to insure efficient combustion. The following table shows the reln. between the percentage CO_2 and fuel wasted:

CO_2	5	7	9	11	13	14	%
Fuel wasted	50	35	27	23	21	20	%

H. G. SCHURECHT

2. Data for fans. ANON. *Brick Pot. Trades J.*, **30**, 11(1922).—The following data was used for successfully installing induced draft and forced draft fans of the multivane type. Let D = outside diam. of impellor in ft.; W = width of impellor in ft.; D_1 = diam. of air inlet; Q = vol. of air in cu. ft. per min.; h = water-gauge pressure in inches; N = r. p. m.; V = peripheral vel. of impeller in ft. per min; Q and h being known, the first thing is to calculate the peripheral vel.

$$V = 3330\sqrt{h}$$

The diam. of the impeller is found next

$$D = \frac{\sqrt{Q \times 3.1416}}{V \times 1.3}$$

The r. p. m. will be found from the above equation

$$N = \frac{V}{3.1416 \times D}$$

The horsepower is given by the formula

$$\text{H. P.} = \frac{Q \times h}{3500}$$

The above formulae are for fans handling air at 50°F, with forced draft fans. In the case of induced draft where the fan has to handle gases at high temps. the decreased d. of the air must be taken into consideration, and the peripheral vel. will now be found to equal

$$V = 3330 \sqrt{h \times \frac{d}{d_1}}$$

where d = density of air at 50°F and d' = density at the temp. of the flue gases; D is as before and Q is the vol. of air at the temp. of the flue gases. The horsepower required will be as before. The propns. of the fan to which the above formula are applicable are:

Width of impellor $W = \frac{D}{2}$

Number of blades = 40 for impellers 9 in. to 15 in. diam.
48 for impellers 18 in. in diam. and upward.

Depth of blades radially $= \frac{D}{10}$

The inside width of casing $= \frac{2D}{3} + 1$ in., the space between the inlet and the impeller being made up by a taper connection leading to the inside circumference of the impeller. The diam. of the air inlet $= D + 1$ in. The width of the discharge opening $= \frac{3D}{4}$. These propns. of discharge openings are maintained no matter what resis. the fan works against, the limit of which for the multi-vane fans is generally 4 to 6 ins. water gauge. The blades are bent to a radius equal to their depth in the larger sizes (30 in. diam. fan and upward) and about $^3/_4$ their depth in the smaller sizes. The above formulae and propns. are not suited for fans operating at a high pressure, such as 12 in. water gauge. The discharge area of fan (A) in sq. ft. is $A = \frac{V}{v}$ where V = vol. of air at normal temps. and pressures in cu. ft. per sec. With most makers the discharge is square in form, and is considerably smaller than that of the fan eye, which is circular, although the former has often an adapter piece fitted to it which expands from square to round, the cir. diam. being equivalent to the fan eye. This taper piece or adapter prevents a sudden drop of air speed, which would have the effect of destroying the dynamic head, and so increasing the total pressure against which the fan would have to work. The adapter can be equally efficient if constructed throughout of rectangular form, and this is nearly always resorted to in the case of fairly large installations. In usual practice the fan inlet $= {}^3/_4 A$. H. G. SCHURECHT

3. Adhesives. P. SCHROT. *Raw Materials Rev.*, **1**, 180(1922).—An agglutinant for veneer is prepd. by mixing together lenzin (an impure gypsum), water, a small quantity of ocher, and leather glue which has been soaked in water for some 14 hrs. O. P. R. O.

4. Burning a down-draft kiln. ELLIS LOVEJOY. *The Clayworker*, **78**, 346–8 (1922).—L. discusses the different stages of burning, namely, water smoking, oxidation, heating up, driving the heat to the bottom, and fire flashing. J. W. HEPPLEWHITE

5. Cause and prevention of smoke in the boiler house. ANON. *Brick Pot. Trades J.*, **30**, 209(1922).—To burn 1 lb. of coal economically 18 lbs of air are required which equals 234 cu. ft. The furnace temp. will be 2750°F, the boiler efficiency 80% and 10 lbs. of water will be evapd. per lb. of coal. In general practice taking the average of 1000 boilers the average wt. of air per lb. of coal was 30 lbs. or 390 cu. ft., the furnace temp. 1700°F, the boiler efficiency 60% and the evapn. per lb. of coal $7\frac{1}{2}$ lbs., 15 cwts. of coal in the first case gives the same evapn. as 20 cwts. in the second. The 25% coal not accounted for is lost as follows. One-fifth is present in the cinders and as small coal under the bars. The same amt. will escape as smoke. The balance is used in heating up uselessly 12 lb. excess air. Black smoke contains 2 grains of C per cu. ft. and if 390 cu. ft. of air is supplied per lb. of coal and this vol. heated to increased temps. it may be doubled and therefore during a black smoke period 1540 grains of coal are lost from every lb. used or over 25%. The rate of heat radiation with a furnace temp. of 2750°F is 3 times greater than when the temp. is 1700°F, therefore, with a clean boiler, 10 sq. ft. of the grate at 2750°F will do as much work as 30 sq. ft. of grate with a temp. of 1700°F. The correct ratio of the grate area to the outlet at the end of the furnace flue is important. This should be 2 to 1 but in practice it varies from 4 to 1 to 2.7 to 1. By giving all sizes of boilers the 2 to 1 ratio the thickness of the fires would be increased and this would automatically cut down the excess air, give increased furnace temp., make black smoke impossible and increase both the duty and the efficiency of both.

H. G. SCHURECHT

6. Use of hot air in continuous kilns. ANON. *Brick Pot. Trades J.*, **30**, 10–11 (1922).—The use of hot air from the cooling goods to watersmoke more brick is the most economical method of drying brick. The transference of ht. from the cooling chambers to those being smoked is effected by means of temporary pipes, the ends of which fit over the feed holes in each chamber. This flue is built along the top of the kiln and runs along its whole length. A short pipe may then be used to connect the flue with the cooling chamber and similar short pipe may connect the flue to the chamber to be smoked. When it is desired to introduce hot air into a chamber of freshly set goods, the caps on the feed holes of that chamber and also those on a chamber containing finished hot ware are removed and the damper between them opened. The increase in temp. is then measured with a thermometer. H. G. SCHURECHT

7. Corrosion in economizers. ANON. *Brick Pot. Trades J.*, **30**, 11(1922).—In the hand-fired boilers firemen rake out the cinders in the red hot state on the floor plate in front of the boilers where they are quenched with water. The vapors are condensed on the economizer tubes causing corrosion of the same. The remedy is to take the refuse direct from the fireholes into suitable receptacles and not rake them on the floor. H. G. SCHURECHT

8. Keeping water out of the clay pit. ANON. *Brick Pot. Trades J.*, **30**, 16(1922).—In open clay-pits the most satisfactory method of drainage is to dig ditches or trenches leading from various parts of the floor of the clay pit to the lowest level of the excavation and there to form a well or sump into which the water can drain and be kept clear of the working parts of the clay pit. Assuming an average rainfall of 28 in. each acre occupied by the clay hole will receive 2830 T. or over 100,000 cu. ft. of water per annum. This very large vol. of water must be removed by either a pump or a syphon (the latter is cheaper but seldom applicable) into a river or drain. As occasionally the rainfall reaches 200 T., or 7168 cu. ft. of water, the catch pit should be large enough to contain at least 10,000 cu. ft. of water for each acre of soil removed, if the catch pit is 20 ft. deep it must have an area of 500 sq. ft. or 25 ft. by 25 ft. H. G. SCHURECHT

9. The firing and the heat economy of the tunnel kiln. M. SPINDLER. *Ber. der Deut. Keram. Gesellshaft*, **3** [4], 171–87(1922).—Ideal burning curves and diagrams

showing the heat distribution and losses from tunnel kilns are given. A saving of 1/3 to 1/2 in fuel consumption is indicated for tunnel kilns compared with round or chamber kilns. When the ratio of air to gas, the gas consumption per hr., and the velocity of the ware are correctly regulated, a high yield of first quality ware will be obtained.
E. N. BUNTING

10. The importance of scientific research in the development of the ceramic industry in North America. K. ENDELL. *Ber. der Deut. Keram. Gesellshaft*, **3** [4], 199–214(1922).—Dr. Endell describes his trip through this country, giving a description of the ceram. schools and the ceram. industries here. He was very favorably impressed by the amt. of research undertaken in ceram., and warns his countrymen that Amer. is likely to surpass Ger. not only in quantity of ceram. products but also in quality. A short history of the AMER. CERAM. SOC., and the St. Louis (1922) meeting is given and the aid given to the industries by ceram. research, especially during the War, is reviewed.
E. N. BUNTING

11. English china clay. ANON. *Times Trade Supp.* (London), **11,** 19(1922).—A Boston member of the Tech. Assoc. of the Pulp and Paper Industry of America in a discussion of the relative merits of English and American clays claims that the English article is superior in colour, is more free from grit and in its greater plasticity possesses those qualities that are peculiarly essential in a coating clay. O. P. R. O.

12. Analyses of mine and car samples of coal collected in the fiscal years 1916 to 1919. ARNO C. FIELDNER AND OTHERS. U. S. Bureau of Mines, *Bulletin* **193.**—Giving the results of analyses of hundreds of coals from 25 States and Alaska. Information on heating values of the coals tested, is given as of interest to users of fuel. Methods for coal sampling and analysis are given, and a bibliography of the coal resources of the world.
R. R. DANIELSON

13. The twelve-hour shift. CHARLES WADSWORTH, 3RD. *Chem. & Met. Eng.*, **27,** 1063–7(1922).—A discussion of the present status of this great problem, and a review of the report of the Federated Amer. Eng. Societies on The Twelve-Hour Shift in American Industry. Includes data on operation of glass, cement, lime, brick, and pottery plants.
R. R. DANIELSON

14. Tables and charts for natural gas users. R. P. ANDERSON. *Chem. & Met. Eng.*, **27,** 1039–40(1922).—Author gives a number of tables and charts to be used in combustion study of natural gas, including computation of excess air, CO_2, heat losses, etc.
R. R. DANIELSON

15. Testing smalt blue. ANON. *Oil and Colour Trades Jour.*, **62,** 1238(1922).—This blue potash glass is obtained by melting zaffer with potash and quartz. For the purest qualities pure cobalt protoxide must be used. The glass is poured into water in a melted state, whereby it becomes very brittle and can easily be powdered; scattering blue is the coarsest, and eschel the finest quality. The presence of foreign metals can largely reduce the value of the smalt; nickel turns it violet when heated, brownish when cold; iron causes a greenish shade; lead and bismuth produce a yellow, manganese a violet, copper oxide a greenish, copper suboxide a reddish coloring. Smalt is often mixed with gypsum and clay.
O. P. R. O.

16. Ball and pebble milling for pulverizing and mixing. H. J. KLINEFELDT. *N. J. Ceramist*, **1** [3], 164(1921).—A paper read before the 7th. National Chem. Exposition in which the author discusses the uses of these mills.
C. W. PARMELEE

17. Importance of grinding. HARRY G. WOLFE. *N. J. Ceramist*, **1** [3], 167 (1921).—Brief statement of the app. used in prepg. potters' materials. C. W. PARMELEE

18. The furnace gas producer. CHAS. W. PARKS. *The Ceramist*, **2** [1], 46–56 (1922).—A description of the furnace gas producer, and comparison of it with the producer gas installation. The furnace gas producer is a simple iron casting which is

fitted to each fire box, thus changing each into a producer. Steam is used in the operation. It may be used either with kilns or under boilers.

TABLE I.—COMPARISON COAL CONSUMPTION AND BURNING TIME

Hand Fired Kiln No. 35

Number brick	29,957
Burning time	6 days
Total coal consumption	56,270 pounds
Total ash per kiln	4,370 pounds
Coal consumption per 1000 brick	2,171 pounds

Furnace Gas Producer Kiln No. 5

Number of brick	28,153
Burning time	3 days, 14 hours
Total coal consumption	41,970 pounds
Total ash per kiln	3,210 pounds
Coal consumption per 1000 brick	1,491 pounds

Coal saving in Kiln No. 5 was 2 days and 10 hrs.

Data is given also showing the use of this gas producer under a boiler as contrasted with the results obtained with the regulation shaker grate. The author summarizes the advantages of the furnace gas producer as follows: "There is no smoke, and therefore no loss in unburned carbon and gases through the stack; no tunnels to build; no expensive burners; no expensive producers; the equipment cannot burn out; a high grade coal is not required, as any coal that will burn can be used; it can be installed as easily as grates; it brings about a better and cleaner product; and it eliminates carbon in ashes. Moreover, it is good for salt glazing, as by simply regulating the steam blast an intense heat can be obtained within the fire-box with clear oxidizing conditions, or a reducing flame can be obtained at a moment's notice, and these are the two factors of greatest importance in salt glazing." C. W. PARMELEE

19. The science of colloids. H. LOEWEN. *Chem.-Ztg.*, **46,** 449–50(1922).—Like Traube (*C. A.*, **16,** 2051), L. believes the term colloidal chemistry is a misnomer since the phenomena dealt with under this head are for the most part not strictly chem. in nature. He points out certain limitations in the theory of colloids but recognizes progress in the technical application of colloids even in the absence of a satisfactory theory.

H. B. W. (*C. A.*)

20. Artificial pebbles for tube milling. A. W. ALLEN. *Mining Sci. Press*, **124,** 405–9(1922).—Owing to the variation in the quality of the pebbles usually furnished, a series of tests are cited for the control of the flint pebbles or others to be used. (1) *Hardness.*—A test piece is cut out of the rock or pebble by a diamond drill and this piece is then revolved against a plate covered with sand for 1,000 revolutions at a uniform pressure. (2) *Toughness.*—This is measured by the blow required to fracture a specified sized piece. (3) *Abrasion.*—Abrasion is measured by the reduction caused by grinding of about 50 pieces of uniform size in a tube mill. Ordinarily the ore itself is not suitable for pebbles; the country rock, ordinarily much larger, is suitable and is used by selection of the correct sized pieces and chipping off the irregular edges, thus making pebbles of only roughly rounded form which will now not chip very much in the mill. A table giving the characteristics of rocks of different states is given and also illustration of various testing appliances are recommended. W. A. M. (*C. A.*)

21. Powdered coal as a fuel in the foundry. A. J. GRINDLE. *Trans. Am. Foundrymen's Assoc.*, **28,** 303–12(1921); *J. Inst. Metals*, **26,** 653–4(1921).—Powd. coal is consid-

ered practical in foundries using 10 tons of coal or its equiv. per day. The manner in which proper combustion can be obtained and the precautions regarding storage and conveyance to the furnace are discussed. V. O. H. (*C. A.*)

22. Artificial precious stones. Hj. Sjögren. *Årksbok Svenska Vet.-Akad.*, **1921**, 288–313; *Mineralog. Abstracts*, **1**, 382.—A review of the literature on artificial gemstones (corundum and spinel) dealing with the production on a com. scale, and the criteria for distinguishing them from natural stones. E. F. H. (*C. A.*)

23. Draft, resistance to draft, and progression of the fire in annular kilns. R. Seydel. *Tonind. Ztg.*, **46**, 64–5, 81–2(1922); *Chimie et industrie*, **8**, 613(1922).—A general discussion of the effects of variations in the resistance offered to the draft, and of the best manner of disposing the bricks to be baked in order to prevent such variations. A. P.-C. (*C. A.*)

24. Application of pulverized coal to boilers. J. W. Fuller. *Trans. Am. Inst. Mining Met. Eng.*, **66**, 701–10(1922); cf. *C. A.*, **16**, 813.—Discussion. J. L. W. (*C. A.*)

25. The use of low-grade fuels in the brick industry. O. Ricklefs. *Arch. Wärmewirtschaft*, **3**, 79–82(1922).—Peat and lignite are good fuels for ring ovens as they give long flames. More heating surface must be provided. Operating details of successful plants are given, and faults pointed out. E. W. T. (*C. A.*)

26. Investigation of the factors influencing the grain and bond in molding sands. C. W. H. Holmes. *J. Iron Steel Inst.*, Advance proof, 22 pp.(1922).—The mechanical and physical properties of sand for gray-Fe founding are as important as the chem. analysis. The bond adsorption value obtained on the raw sand may be greatly modified by mechanical treatment. The most successful molding sands contain both static and mobile bond. An appreciable degradation of the grains of a molding sand occurs during the mechanical prepn. as usually effected. The bond distribution factor is a characteristic of molding sands that is of great importance in view of the excessive degradation which may be caused by prolonging milling beyond the time needed to effect the optimum distribution. No single test is sufficient on which to judge the practical value of many molding sands, but a careful consideration of all those tests mentioned should be included. V. O. H. (*C. A.*)

27. Early chemical industry in America. A few comparisons of past and present conditions. C. A. Browne. *J. Ind. Eng. Chem.*, **14**, 1066–71(1922). E. J. C. (*C. A.*).

28. Weathering of Belgian bricks. Chr. K. Visser. *De Ingenieur*, **37**, 135–41 (1922).—Bricks, manufd. in Belgium and used for building in Holland, frequently become covered with a mold-like efflorescence, then crack and become soft and brittle. The efflorescence is almost entirely $MgSO_4$. The crystn. of this salt, involving an increase of vol., causes the disintegration of the brick. From new bricks up to 2.38% $MgSO_4$ can be extd. by H_2O. The clay from which the bricks are made contains much less $MgSO_4$ than the bricks; a part of the S is believed to be derived from the combustior gases of the furnace. If the bricks are heated to 900° $MgSO_4$ can no longer be extd. Heating to 900° or higher is, therefore, the best way of obtaining bricks which do not decay, even if $MgSO_4$ is present. Another remedy is the use of "fat" cement, contg. much $Ca(OH)_2$, which decomposes $MgSO_4$, forming insol. $Mg(OH)_2$, thus preventing efflorescence. R. B. (*C. A.*)

Apparatus and Instruments

29. Electric heating and controlling apparatus for small thermostat. S. O. Rawling. *J. Soc. Chem. Ind.*, **41**, 250–1T(1922).—This control operates by short circuiting a part of the resistance in series with an elec. heater when the temp. falls below the working level. Short circuiting is done by a relay system operated by a regulator consisting of a Hg make-and-break actuated by expansion and contraction of toluene. The

operating temp. is easily altered by a simple adjustment of the vol. of the working fluid, and position of the contacts. With room temp. at 15°, 27 l. of H_2O are kept at 25 ± 0.02°. D. E. S. (*C. A.*)

30. A new carbon dioxide recorder. ANON. *Electrician*, **89,** 15(1922).—This CO_2 recorder is elec. in operation, requires no chem. absorbent, has no delicate glass work and is claimed to be very active and sensitive. The meter contains 2 identical spirals of Pt wire enclosed in separate cells in a metal block. One cell contains air satd. with water vapor and the other is open to the flue gases. The Pt spirals form 2 arms of a Wheatstone bridge circuit. When the current flows, the spirals become heated, losing heat to the walls of the cell, their temps. and resistances depending on thermal conductivities of gases surrounding them. CO_2 changes in the gas cause changes in its cond. and a consequent change in the galvanometer deflection. The indicating or recording galvanometer may be calibrated to give direct readings on % CO_2. A portable CO_2 and temp. outfit is illus. and briefly described. It is enclosed with the recorder. Current is supplied by dry cells fitted into the lid of the case. When CO_2 readings are desired the flue gases are drawn past the CO_2 water by pressing a rubber bulb and the multiway switch is turned to the CO_2 position. For temp. readings a thermocouple is placed in the flue and connected by the 2 terminals, and the switch is turned to the position marked "couple." Each app. is illus. W. H. B. (*C. A.*)

31. A new thermo-regulator for the thermostat. PRIMO DORELLO. *Arch. farmsper.*, **33,** 184–5(1922).—The jacket of the thermostat is filled with mineral oil which has a coeff. of expansion about twice that of H_2O. The upper surface terminates in a tube of such diam. that the change in vol. of the oil caused by a rise or fall of 1° causes a difference in level of 1 cm. in the tube. A float in the tube is connected with a lever which makes and breaks the current passing through the heating coil. The oven is const. to 1° and may be set for temps. between 30° and 60°. A. W. D. (*C. A.*)

32. Refractometer for the determination of solid and liquid substances. C. LEISS. *Z. Krist.*, **56,** 524–6(1921).—Description with fig. of an instrument of the hemisphere type with several new appliances increasing its convenience and accuracy. P. B. (*C. A.*)

33. Electric precipitation of dust. A. VOSMAER. *Chem. Weekblad.*, **18,** 262–3 (1921).—A review of methods used in copper refineries, tunnels and cement works. NATHAN VAN PATTEN (*C. A.*)

34. Electrical flue-gas examiner. C. O. FRIEDRICH. *Chem.-Ztg.*, **46,** 848(1922).—An app. is described for the continuous examn. of flue gases. The flue gases pass over a wire which is elec. heated by a feeble current. The change in the resistance of this wire is measured by means of a Wheatstone bridge arrangement with which is connected a continuous recording device. Since the thermal cond. of CO_2 is only about 0.5 that of air or CO, the resistance of the wire is greater the higher the CO_2 content in the flue gases. H. JERMAIN CREIGHTON (*C. A.*)

35. Measurement of thermal conductivity of liquids, insulators, and metals. MAX JAKOB. *Z. Ver. deut. Ing.* **66,** 688–93.—J. describes the methods and procedure, which are very similar to those already used for water (*C. A.*, **15,** 977). For application in modern technical practice the temp. coeff. of the cond. is shown to be important. J. had found this positive for water, and equal to 0.003, while Lees had found it negative. For toluene at 20°, 0.000443 is found (much higher than results by most other experimenters). Lees' result for alc. is pronounced unsatisfactory. Some 30% Ni steels gave the very low value of around 0.029 at about room temp., 0.031 at 72° The importance of such metals is emphasized. W. P. W. (*C. A.*)

36. Report of committee on colorimetry for 1920-21. L. T. TROLAND. *J. Optical Soc. Am.*, **6,** 527–96(1922).—An attempt is made: (1) to clarify and standardize color

terminology; (2) to compile data fundamental to color science; (3) to specify standard stimuli and conditions for practical work; and (4) to encourage discussion and research along these lines. F. O. A. (*C. A.*)

37. Apparatus for measuring high temperatures. O. FRIEDRICH. *Z. Sauerstoff-Ind.*, **13**, 117–20(1921); *Chimie et industrie*, **8**, 589(1922).—The *Holbern-Kurlbaum pyrometer* consists of a telescope focused on the body or the point of which the temp. is required. An incandescent elec. bulb is placed in the telescope in such a manner that the image of the filament is projected on the incandescent surface. By means of a suitable resistance, the intensity of the filament is adjusted so that its image loses itself in that of the hot body. At this point the temps. of the two are same. It is obtained from the deflection of a suitably calibrated galvanometer. The *ardometer* is intended to be attached to the wall of a furnace, for example. The radiations from the incandescent body are concd. by means of lenses on a small metal plate which heats up. It is placed at the junction of a thermoelec. couple. A. P.-C. (*C. A.*)

38. A simple instrument for testing refractive indices of liquids. R. FOURACRE. *Pharm. J.*, **109**, 88–9, 105; *Chemist and Druggist*, **97**, 169–70(1922).—A small elec. bulb is used as the object and placed in the focus of a convex lens. The beam of parallel rays produced is sent downward through the combination of a convex lens resting on a glass plate, with the liquid to be examd. between the two. By moving the combination, along a vertical scale, the light is brought to a focus on a plane surface, showing the image of the filament. The distance between the upper surface of the glass plate and the image will be the focal length (d) of the combination of lenses. The focal length of the glass lens used being known, *e. g.*, 20 cm., then $n_{\text{liquid}} = 2 - 20/d$. The development of this formula is given. A table shows values of n for changes of d from 20 cm. to 61 cm. For a 20 cm. length, n varies from 1.000 to 1.672. The temp. of the liquid may be taken into account by putting the glass plate and lens into H_2O of the required temp. for a few min. before use. S. WALDBOTT (*C. A.*)

39. Modern radiation pyrometers. L. NEURAY. *Rev. universelle mines*, **6** [6], 127–43(1920); *J. Inst. Metals*, **26**, 580.—The theory and design of radiation pyrometers are discussed, and descriptions are given of all the best-known makes. H. G. (*C. A.*)

40. A jointed microscope for laboratories and work shops. M. v. SCHWARZ. *Z. Metallkunde*, **12**, 366–7(1920).—A microscope with adjustable socket joints for the examn. of large specimens and of specimens in position is described and illustrated. R. S. W. (*C. A.*)

41. A new elutriator for rapid use. T. M. LOWRY. *J. Oil Colour Chem. Assoc.*, **5**, 92–3(1922).—A serious objection to the use of the elutriator for controlling the efficiency of a grinding plant is that it is necessary to take out and weigh the coarse residue remaining after elutriation. This may be overcome by gradually tapering the lower end of the vertical tube into a graduated capillary of 2 mm. diam. After calibrating the tube for a given substance, residues can be read volumetrically. Illus. Discussion. F. A. WERTZ (*C. A.*)

42. Kinetic flocculation meters. I. WO. OSTWALD AND F.-V. v. HAHN. *Kolloid-Z.*, **30**, 62–70(1922).—A 2-legged flocculation meter has been developed from Wiegner's app. for soil analysis (*C. A.*, **14**, 84). It consists of two tubes 130 cm. long, joined in a U by a capillary at the bottom and fitted with a scale near their upper ends. It depends on the change in d. of the soln. during flocculation and sedimentation. The comparison liquid is placed in the narrower tube, which has a stop-cock at the top and the soln. in the wider one which has a stoppered outlet at the bottom. Both tubes are fitted with bulbs which minimize the errors due to mixing. The app. is filled and the stop-cock opened. The difference in level is read immediately and at intervals thereafter. The app. was used with Ag_2S and HgS solns. The difference in level is plotted

against the time in min. after addition of an electrolyte. When 25 millimoles of KCl per 1. were added to Ag_2S soln. made from 0.1 *N* $AgNO_3$, a coarse dispersion, which started to settle immediately, resulted. Sedimentation started only after 25 min. with a sol made from 0.00286 *N* $AgNO_3$ soln. Sols of intermediate concns. gave points between, and a curve connecting these points forms the *stability surface* characteristic of the soln. Increasing the concn. of KCl decreased the stability surface. HgS solns. were much more stable than Ag_2S. In the 1-legged flocculation meter the soln. is used to confine a gas under diminished pressure. As the flocculation proceeds, the change in height of the soln. is detd. at intervals. The 1-legged meter is more sensitive to temp. than the 2-legged one but the differences in level are greater and there is no mixing of liquids. The former was tried with *Ag_2S, HgS, mastic,* and *Au solns.* It gave a stability base-line when the change in level was plotted against the time. The time to the beginning of sedimentation with Ag_2S solns. was the same with both instruments. A blue Au soln. started to settle in 4 min., a red one in 16. Peptization probably could be measured with either app. WM. STERICKER (*C. A.*)

PATENTS

43. Viscosimeter. L. L. TIFFANY. U. S. 1,427,922, Sept. 5. The app. comprizes tubes of glass or other transparent material, in which oil or other substance to be tested is placed, and grooved plungers fitting snugly within the tubes serve as testing devices by the time required for their descent by gravity through the material. (*C. A.*)

44. Thermostats. GENERAL ELECTRIC CO. Brit. 181,645, Oct. 11, 1921. Bi-metallic-strip thermostatic elements, particularly those intended to be heated by an elec. current are formed of two materials both having relatively high elec. resistance but with thermal characteristics which are dissimilar even at high temps., such as 500°F. Preferably, the materials of both portions of the strip contain a substantial % of Ni, one being composed of a nickel steel alloy such as invar, and the other being composed of a Ni-Cu alloy or of nichrome. Suitable proportions for a Ni-Cu alloy are 82% of Cu and 18% of Ni. (*C. A.*)

45. Thermometer support for use in kilns. D. D. BUNDRICK. U. S. 1,430,937, Oct. 3. A frame is provided with a handle and cross bars for holding wet and dry bulb thermometers. (*C. A.*)

Chemistry, Physics and Geology

46. The dissociation of clay by lime. E. SELCH. *Sprechsaal,* **55,** 1, 2(1922).—In previous work (*Sprechsaal,* **173,** 1916), the effect of CaO upon ceram. bodies was studied. After the bodies had been fired the silicic acid and alumina sol. in HCl and NaOH were detd. At cone 04a it is necessary to have two mol. of CaO present to decompose one mol. of clay. After firing at cone 9 it is necessary to have only one mol. of CaO present to decompose one mol. of clay. In this work the above tests were continued more thoroughly. Different mixt. of lime and clay were fired to different temps. and the per cent material sol. in HCl and NaOH were detd. It was found that the higher the lime content the more thoroughly was the clay decomposed after firing. A mixt. of one mol. clay and 2 mol. of CaO is almost entirely sol. in HCl after firing to cone 1a. The CaO even when fired to a high temp. in a lime-clay mixt. is almost entirely sol. in HCl. In some cases the mixt. becomes more sol. when fired to the higher temps. whereas in others it becomes less sol. H. G. SCHURECHT

47. Formation of clays. ANON. *Brick Pot. Trades J.,* **30,** 14(1922).—The big difference in the properties of clays from various localities is attributed to their different methods of formation. Feldspars appear to be the origin of true kaolins whereas the clays derived from porphyry and basalt appear to be different from kaolins. The climatic conditions under which clays are formed are also important. In tropical

climates laterites are formed with a considerable amt. of iron, but in milder climates clays containing less iron are formed. The difference lies in the effect of humus on the formation of the clay, the propn. of humus being greatest in milder climates. The method of transportation whether by water, ice or wind also exerts an important influence on the properties of clays. Fire clays although free from most of the fusible impurities often have nodules of pyrites and marcasite which have been formed by the decomps. of vegetable matter in clay, and its action on the iron compds. present.

H. G. SCHURECHT

48. Bauxite clay. Ayrshire. G. V. WILSON. *Memoir Geol. Sur.* (Scotland), **1922.**—This Memoir contains an account of the geology of the Ayrshire bauxite clay deposit, its petrology, chemistry and probable mode of origin, and of its characters in the different areas where it is proved. O. P. R. O.

49. A new process for utilizing feldspar. ANON. *Can. Min. Jour.*, **43,** 790 (1922).—C. M. Brown, Toronto, has just perfected a new method of treating feldspar which makes all three of its constituent oxides commercially marketable commodities. The process is the application of acid gases to finely ground feldspar in a rotary kiln at low temperatures. The finished products are obtained by leaching and crystallization. Continuously recovering of chemicals and the avoidance of high temperature keeps the costs down to a point where operating profits are demonstrable. O. P. R. O.

50. Purification of clay. W. R. ORMANDY. *Chem. Trade Jour. & Chem. Eng.*, **69,** 750(1921).—History of osmosis method is given. In treating a very pure specimen of a well-washed English china clay by the osmose process, it has been found possible to deposit as much as 6,833 kilograms of dry-clay substance with 11.8 kilowatt-hours of current, when working at 50 volts pressure. The electro-osmotic process does not bring about any purification of the clay material in the actual osmose machine, but whatever may be the position theoretically, the fact remains that in practice such a purification is brought about, as has been proved beyond all doubt at the laboratory of the Osmosis Co., Ltd., by Mr. Lawrie, when working on tons of china clays and ball clays. (Contribution to the General Discussion on the Physics and Chemistry of Colloids and their Bearings on Industrial Questions, held by the Faraday Society and the Physical Society of London, on Oct. 25, 1920.) O. P. R. O.

51. Rocks rich in barium. (New South Wales.) ANON. *Memoir*, No. **8,** *Geol. Sur. of New South Wales.*, p. 337(1922).—A remarkable rock type has been found in the vicinity of Broken Hill, N. S. W., which appears to be unique in petrology. In hand specimen it is finely grained, of a greyish white colour, and looks not unlike an aplite. On closer view it appears to consist mostly of feldspar, with a few thin parallel streaks of a darker mineral. Its sp. gr. is notably higher than one would expect in such a rock. Analysis shows it to contain more than 9% of barium oxide, which is quite unique among silicate rocks. It seems most reasonable to suppose that the barium is contained in the feldspar, but a calculation shows that there is not enough alumina present in the rock to satisfy the feldspar formula, assuming all the barium and lime to be present in this mineral. The matter must remain unexplained for the present.

O. P. R. O.

52. Mineral colours. (India.) J. COGGIN BROWN. *Bull. Indian Industries*, No. **22**(1922).—The mineral colours may be divided into 3 groups as follows: (1) Natural mineral pigments. (2) Pigments made directly from ores or ore residues. (3) Chemically manuf. pigments. Group (1) includes the ochers, oxides, umbers, siennas, ground slate and shale. Group (2) includes sublimed white lead and sublimed blue lead (both of which are basic sulphates made directly from galena), zinc oxide and the red oxides made by burning spent pyrites. Group (3) includes a very large number of colours, such as white lead, chrome yellow, Prussian blue, etc. O. P. R. O.

53. China clay in Quebec. ANON. *Can. Chem. & Met.*, **6**, 243(1922).—The Canadian China Clay Co. is now operating deposits at Huberdeau, Quebec. The kaolin zone is about 1,000 feet wide and 7,000 feet long, but has not been fully prospected. The china clay occurs in veins and pockets in quartzite rock and although much of it is stained with iron it makes a very good fire clay. Regular mining methods are used. A shaft of 100 feet has been sunk and a lens of some 200 feet by 60 feet developed. O. P. R. O.

54. Mineral Pigments. (Queensland.) ANON. *Imperial Inst. Bull.*, **20**, 244 (1922).—In the Triassic rocks of Queensland, valuable deposits of oxides and ochers have been found. These are in the neighborhood of Cape Flattery, where there is scope for industry in earth colors. Samples of quartz sand washed from these pigment deposits in the course of refining have been investigated at the Imperial Institute, and found to be suitable for the manufacture of glass, for such purposes as the production of pale-tinted bottles. O. P. R. O.

55. Aluminium. (Russia.) ANON. *Mining Jour.*, **135**, 883(1921).—The alunite shales; the clays known as suchar and containing 40% alumina; and the nepheline rocks rich in aluminium, are not of value under present conditions. Of greater importance are the deposits of pure bauxite and similar rocks. The area of these deposits at present defined, is about 88 sq. mi., and the bauxite is irregularly distributed over this area, mostly in the form of pockets. Though bauxite deposits were discovered as long ago as 1882, only a little superficial work has been done on these Russian deposits. O. P. R. O.

56. Chemistry of alunite. H. BOWLEY. *J. Proc. Roy. Soc. W. Australia*, **7**, 48–83(1920–1).—Alunite from Kanowna (W. Australia) is white, finely cryst., very porous (28–58% air space), with sp. gr. = 2.65, n = 1.58. The transparent grains are pseudocubical rhombohedra. Eight analyses of alunite and Na-alunite are given. Up to 300° alunite is unaffected by dry heat. At 400° $4^1/_2$ mols. of H_2O are lost, by 500° the remaining $1^1/_2$ mols. are removed. On heating to 800° alunite is completely dissociated into K_2SO_4, Al_2O_3, SO_3, and H_2O. By 960° the K_2SO_4 dissociates and reacts with Al_2O_3 to form sol. K aluminate. Alunite is readily sol. in warm dil. solns. of HF, NaOH, KOH, Na_2CO_3 and hot strong H_2SO_4; slowly sol. in warm Na_2CO_3 solns.; moderately sol. in HCl and warm dil. H_2SO_4; sparingly in H_2O. It is attacked fairly readily by a $Ca(OH)_2$ soln. and appreciably by $CaCO_3$ solns. E. F. H. (*C. A.*)

57. The variation of the specific heat during melting and the heat of fusion of some metals. ITIRÔ ITAKA. *Science Repts. Tôhoku Imp. Univ.*, **8**, 99–114(1919); *J. Inst. Metals*, **26**, 505.—The sp. heats of Na, Bi, Pb, Sn and Zn have been detd. in the liquid and solid states at various temps. There is a discontinuous change on melting, being an increase for Na, Bi, and Zn, but a decrease for Pb and Sn. The sp. heat in the liquid state is independent of temp. The latent heats of fusion of the same elements have been detd. H. G. (*C. A.*)

58. The chemical constitution of feldspars. Analysis of two microclines. M. E. DENAEYER. *Bull. soc. chim. Belg.*, **31**, 131–47(1922).—Theories of the constitution of complex silicates (W. and D. Asch, "Die Silicate," Berlin, 1911; P. Erculisse, "Classification chimique des silicates naturels," Brussels, 1920; J. Jakob, *C. A.*, **15**, 36) are discussed, and an attempt is made to apply Werner's coördination theory to the problem. Some formulas based on the latter theory are given and a pseudo-phase rule diagram based on these is used to suggest the mutual relationship of quartz, orthose, plagioclases, micas, and spinels. The connection between the views put forward by Jakob and by F. W. Clarke is briefly discussed. The analysis of two microclines (triclinic potash-soda feldspars) is considered to indicate that they are built up of 3 sep. components in solid soln., and a study of results of analyses carried out by other workers tends to confirm this view. J. C. S. (*C. A.*)

59. Studies at high temperatures. XV. The vapor pressures of the alkali fluorides. OTTO RUFF, GERHARD SCHMIDT AND SUSANNE MUGDAN. *Z. anorg. allgem. Chem.*, **123,** 83–8(1922); cf. *Ceram. Abs.*, **1** [3] 60.—Vapor pressure-temp. curves for the fluorides of Cs, Rb, K, Li and Na are given between pressures of about 50 mm. Hg and 1 atm. For exptl. methods of. The curves are roughly parallel, and the order of metals given above is the order of decreasing vapor pressure at any temp. For any given pressure Rb has a curve about 160° above Cs, K about 80° above Rb, Li about 180° above K, and Na about 30° higher yet. The centigrade boiling points are:

LiF	NaF	KF	RbF	CsF
1670	1705	1498	1408	1253

Heats of vaporization, the Ramsay-Young consts., and *critical temps.* (from the Guldberg-Guy rule) are calcd. A. E. S. (*C. A.*)

60. A simple method for the estimation of the soda content of a potash. L. SPRINGER. *Sprechsaal*, **54,** 328(1921); *J. Soc. Glass Tech.*, **5,** 143–4.—If the alky. of a sample of potash is due entirely to Na_2CO_3 and K_2CO_3, the content of each can be detd. by a single titration with acid. With 3.45 g. of sample, each cc. of 0.1 *N* acid over the vol. required to neutralize this wt. of pure K_2CO_3(50.0 cc.) indicates 6.63% of Na_2CO_3. W. T. H. (*C. A.*)

61. Crude aluminium ores in Hungary. B. HORVÁTH. *Termeszettud. Közlöny* (Budapest), **47,** 795–804(1915); *Mineralog. Abstracts*, **1,** 385.—Hungarian bauxite deposits are located in the Bihar Mts. Eight analyses are given. Bauxite ores of other countries are briefly discussed. E. F. H. (*C. A.*)

62. Data on colloidal clays. J. SPLÍCHAL. *Zemědělsky Archiv. Prague*, **10,** 413–31 (1919); *Mineralog. Abstracts*, **1,** 288.—The only reliable test for amount of colloidal clays in the products of weathering is that given by the hygroscopicity and not that given by the adsorption of coloring matters or salt solns. The *n*s. for various colloidal clays before and after ignition are given; also for a series of artificial gels after ignition. The *n* decreases with increasing silica. E. F. H. (*C. A.*)

63. Chemical relations of kaolinite at high temperatures. JOS. MATĚJKA. *Chem. Listy*, **13,** 164–6, 182–5(1919); *Mineralog. Abstracts*, **1,** 287.—The soly. of kaolinite in boiling *N* NaOH at 110–1100° is given. The water goes off at 500–600°, and above 1100° there exists only a mixture of fibrolite and cristobalite, whereas at the lower temps. several Al silicates exist. E. F. H. (*C. A.*)

64. The chemical constitution of silicates. B. GOSSNER. *Centr. Mineral. Geol.*, **1921,** 513–25.—A theoretical paper in which G. criticizes current views as to the chem. constitution of silicates. Attempts to deduce from the chem. compn. of a crystal the constitution of the corresponding mol. unit are fallacious. It is pointed out that the existence of complex silicates such as $(SiO_4)_2Al_2Ca$, or Si_3O_8AlK at the high temps. at which the corresponding minerals were formed is most improbable, for the chem. affinities of silica and alumina, slight at ordinary temps., diminish at higher temps. For similar reasons, the existence in minerals of such radicals as $—Al(OH)_2$ is inconceivable. G. endeavors to show that, by postulating the existence of a limited no. of simple stable silicates as mol. individuals, the structure of more complicated silicates can be explained as due to combinations of these. Without inquiring further into the nature of the combination of the simpler silicates to the more complex forms, this may be taken as similar to that existing in cryst. double salt or in solid compds. contg. water of crystn. The simple silicates postulated are SiO_2Na_2, SiO_3Ca, SiO_3Mg, SiO_2, Al_2O_3, all of which can readily be obtained cryst. from the fused state. When water is a constituent of a silicate crystal, hydroxides such as $Ca(OH)_2$ or $Mg(OH)_2$ may be present, and, in certain circumstances, AlO_2H and AlO_3H_3, both of which are known in the cryst. state. From this point of view the compn. of several groups of minerals is discussed, particularly in

relation to the paragenesis of the minerals. As an example, in the alkali-lime-silicate group, the following formulas are given: nepheline, SiO_3Na_2, $[SiO_2,Al_2O_3]$; leucite, SiO_3K_2, $[SiO_2,Al_2O_3]$, $2SiO_2$; albite, SiO_3Na_2, $[SiO_2,Al_2O_3]$, $4SiO_2$; anorthite, SiO_3Ca, $[SiO_2,Al_2O_3]$. These formulas bring out well the relationships between the minerals of this group, the fact that nepheline and anorthite have sharp m. ps. while the others have not, and that the former pair more readily undergo secondary changes in geological deposits, for instance into zeolites, while the others behave as if they were in a sense more satd. Numerous other groups are also discussed. J. C. S. (*C. A.*)

65. Aluminium hydroxide and "aluminic acid." ROBERT FRICKE. *Z. Elektrochem.*, **28,** 357–8(1922).—Polemical against F. Goudriaan (cf. *C. A.*, **15,** 478; **16,** 2088). H. J. C. (*C. A.*)

66. Report from the chemical laboratory of the Royal Hungarian Geological Survey. B. HORVÁTH. *Magyar Kir. Földtani Intézet Jelentése* (Budapest), **1915,** 471–86; **1916,** 511–30; *Mineralog. Abstracts*, **1,** 385.—Numerous analyses of rocks, clays, soils, phosphatic earths from caves, ores, coal, and waters are given. Analyses of 4 bauxites from Com. Bihar gave: Al_2O_3 56.77–64.61, Fe_2O_3 2.84–25.82, SiO_2 1.39–11.56, TiO_2 1.05–3.86, CaO trace–3.07, MgO up to 3.05, H_2O 0.09–0.45, H_2O + 11.19–14.20%. E. F. H. (*C. A.*)

67. System Fe_2O_3–SO_3–H_2O. E. POSNJAK AND H. E. MERWIN. *J. Am. Chem. Soc.*, **44,** 1965–94(1922).—This system was investigated over the temp. range 50° to 200° and the following cryst. phases were encountered: Fe_2O_3; $Fe_2O_3.H_2O$; $3Fe_2O_3.4SO_3.9H_2O$; $Fe_2O_3.2SO_3.H_2O$; $Fe_2O_3.2SO_3.5H_2O$; $2Fe_2O_3.5SO_3.17H_2O$; $Fe_2O_3.SO_3$ (2 forms); $Fe_2O_3.3SO_3.6H_2O$; $Fe_2O_3.3SO_3.7H_2O$; $Fe_2O_3.4SO_3.3H_2O$ and $Fe_2O_3.4SO_3.9H_2O$. The conditions under which these substances are formed, the ranges of their stabilities, and their relations to one another, also some of their crystallographic and optical properties, were determined. The data obtained are presented by means of tables and graphically by means of curves and a solid model. J. M. B. (*C. A.*)

68. Diffusion of hydrogen and helium through silica glass and other glasses. G. A. WILLIAMS AND J. B. FERGUSON. *J. Am. Chem. Soc.*, **44,** 2160–7(1922).—Both H and He diffuse through silica glass. The permeability is proportional to the pressure and is an exponential function of the temp. The permeability to H becomes appreciable above 300° and to He is easily measured at 180°. At 500° the permeability to He is about 22 times that to H. Both Pyrex glass and Jena combustion glass are impermeable to H; the former, however, becomes black. The Jena glass is permeable to He. J. M. B. (*C. A.*)

69. Specific heat gases. G. A. BRENDER À BRANDIS. *Het. Gas*, **41,** 255–9(1921).—Four tables are given: (1) true sp. heat at const. pressure per kg., (2) av. sp. heat at const. pressure per kg., (3) true sp. heat at const. pressure per cu. m., (4) av. sp. heat at const. pressure per cu. m. These data cover the range of temps. from 0° to 3000°, and are for SO_2, O, N, CO, H, air, and water vapor. N. V. P. (*C. A.*)

70. The white clay industry in the vicinity of Langley, So. Carolina. W. M. WEIGEL. Bur. Mines, *Repts. Investigations*, No. **2382,** 6 pp.(1922).—Details of mining methods and prepn. for market are given. The kaolin occurs as lenses with 5 to 75 ft. overburden. Three analyses show: SiO_2 44.00–44.66, Al_2O_3 37.90–40.25, Fe_2O_3 1.43–2.53, TiO_2 1.25–1.50, CaO 0.08–0.28, MgO trace, alk. 0.40–0.77, ign. loss 12.14–13.17. Rational annal. of 2 samples showed: clay substance 99.29, 99.60; quartz 0.49, 0.16; feldspar 0.47, 0.64. The clay is used chiefly for paper making, also for pottery and china without washing. C. H. K. (*C. A.*)

71. The color of iron oxides. J. A. HEDVALL. *Z. anorg. allgem. Chem.*, **121,** 217–24(1922).—Fe_2O_3 may assume different tints depending on the temp. of formation and the duration of heating. These may all be divided into 2 groups, the bright orange,

red, and the darker colors. The first is prepd. by heating $Fe_2(SO_4)_3$ at a temp. below 650°. The differences in color may be due to different modifications or to different crystal structures. Microscopical examn. of 27 samples of Fe_2O_3 showed that all were composed of grains except that prepd. from $Fe_2(SO_4)_3$, which was in the shape of plates or scales. The difference in color is due to the difference in the reflection of light from the different shapes of crystals. F. E. B. (*C. A.*)

72. Preliminary report on the bauxite occurrences of northern Bihar (Királyerdö). P. ROZLOZSNIK. *Magyar Kir. Földtani Intézet Jelentése* (Budapest), **1916,** 450–4; *Mineralog. Abstracts,* **1,** 385.—These are ferruginous bauxites, red or light-brown, with Al_2O_3 over 53%. They occur as beds or lumps between limestones. Near diorite they are metamorphosed, are darker, and contain pyrite and diaspore. E. F. H. (*C. A.*)

Refractories and Furnaces

73. Fire clay refractories. ALAN G. WIKOFF. *Chem. & Met. Eng.,* **27,** 969–71 (1922).—An outline of manufacturing operations at the Laclede-Christy Clay Products Co., St. Louis, in the production of dry-press and stiff-mud process fire brick, special shapes, glass house refractories, and washed pot clay. R. R. DANIELSON

74. Manufacture of fire clay refractories. ALAN G. WIKOFF. *Chem. & Met.,* **27,** 505(1922).—An outline of plant operations at the Even & Howards Fire Brick Co., St. Louis. Gives a description of plant layout, of raw materials used and their preparation, and of forming, drying and burning of brick. Mfg. operations are coördinated by the planning dept. to obtain max. production efficiency. R. R. D.

75. Thermal conductivity of refractories. W. A. HULL. *Chem. & Met.,* **27,** 538(1922).—A review of the literature on thermal conductivity of refractories. Hull cites work done by Wologdine, Dudley and by Dougell, Hodsman and Cobb The latter give formula for computing coeff. of thermal conductivity (K_t) for temp. to 1000°C.

Fire clay brick, $K_t = 0.00155 + 0.25 \times 10^{-5}\, t$.

Magnesia brick, $K_t = 0.0285 - 0.379 \times 10^{-4}\, t + 0.179 \times 10^{-7}\, t^2$.

H. considers the work of latter two investigators as satisfactory for ordinary engineering purposes, but calls attention to the need for a std. method of making routine conductivity tests of commercial materials. R. R. D.

76. Refractories, with special reference of recent developments. W. F. ROCHOW. *N. J. Ceramist,* **1** [3], 181(1921).—General discussion of the properties of silica brick, its physical characteristics and uses in the steel and glass industry, lime kiln linings and muffle furnaces. *Clay refractories and their testing.*—Soapstone has been supplanted with good results by the use of a good quality of machine-made fire brick in the sidewalls and bottoms of lead smelting furnaces. The general trend of the development in clay refractories has been toward the use of better grades. All-clay steel-melting crucibles are more widely used now than previously. This demand is regarded as temporary, as greater care is required in handling the all-clay product. Heretofore, the English Stourbridge and Stannington clays have been used almost exclusively. Good results can now be secured with combinations of Ohio and Pennsylvania clays; in most cases even better service has resulted from the use of all Amer. clays. *Carbon or graphite refractories.*—Combinations of domestic clays have given superior service when substituted for German clays. *Basic refractories.*—Sufficient experience has been had to make evident the fact that dolomite cannot be used economically in place of magnesite. *Patent metalkase magnesia brick.*—"Patent Metalkase Magnesia Brick" are made by filling soft steel containers with ground calcined magnesite. The use of these brick promises an increased life of from 15 to 25 times over that of silica, and about three times that of magnesia brick. *Bauxite brick.*—A bauxite brick of approx. 56% alumina has been manufd. commercially for several years, which finds its chief application

as a lining of rotary kilns used for burning Portland cement, also, along the clinker lines in boiler settings. C. W. PARMELEE

77. The expansion of silica brick in coke ovens. ANON. *Brick Pot. Trades J.*, **30,** 6(1922).—Silica brick used for coke ovens in England are made of a mixt. of clay and silica rock containing less than 84% SiO_2. Brick containing a higher SiO_2 content expand too much in firing. This expansion takes place much more rapidly at high temps. than it does at low temps. For this reason silica brick which may safely be fired at 1200°C spall badly when fired rapidly to 1400°C. Tridymite has the least expansion when heated but it has not yet been found practical to make brick wholly of tridymite. The best that can be done is to burn brick thoroughly at a temp. sufficiently high to reduce this expansion to a minimum which is about 1400°C. H. G. SCHURECHT

78. Mechanical handling. ANON. *Brick Pot. Trades J.*, **30,** 34(1922).—The use of mechanical conveyors in the place of barrows is yet in its infancy. A mechanical conveyor can place brick in a drier as well as a skilled youth can place them on a drier floor. If the conveyor is to be used, however, it will be necessary to use pallet driers in the place of hot floor driers. For unloading coal and carrying it to the boiler of kiln a mechanical conveyor is much more rapid than a man but where the stoker and burner have to wheel the coal as part of their daily work there is no direct gain in using a conveyor. Few firms have realized how much more clay can be loaded into wagons if a mechanical loader were used instead of the men at the clay face using shovels. There are several mechanical loaders on the market which will work their way into the bank of loose clay or shale and load it at the rate of 15 tons per hr. They consist of a modified bucket elevator with self-contained engine and a device for filling the buckets automatically. With such a device two men can throw down and load all the clay or shale required for an output of ten million brick without the men being unduly tired.
H. G. SCHURECHT

79. British Siemens furnace practice. FRED CLEMENTS. *J. Iron Steel Inst.*, **50,** 429–90(1922).—This paper does not discuss the subject from the refrac. standpoint, but makes numerous references to the refrac. problems involved. The opinion was expressed that the silica brick made today can hardly be improved to meet more severe temp. conditions. Inasmuch as they are pushed to the limit at present, any increase in temp. must be accompanied by changes in furnace design to keep the hotter flame from the brickwork. He believes that 15% of the heat can be saved by insulating the regenerators and flues. Checkers are discussed from the following angles: (1) Correct weight of effective brickwork, (2) Maximum heating surface possible per unit volumes, (3) Proper distribution of gases over checkers, (4) Best velocity through the checkers to give the most effective heat interchange. Expts. showed that with half-hour reversals the outer inch of a refrac. brick is the only effective portion and that a brick 2" thick is the most economical. The percentage of ht. interchanged is very small in propn. to that which is stored in the checkers. A table of sp. hts., sp. gr., and conductivities is given. In discussing the paper practical men do not favor insulating refractories as the duty is more severe, but on the other hand favor water cooling. 95% of the doors in the U. S. are water-cooled, while the percentage in England is low. Dr. Rosenhain erroneously states that insulation does not impose more severe conditions if allowance is made in the fuel used. He does not recognize the fact that the temp. gradients are completely changed with insulation. R. M. HOWE

80. Properties of refractories under load at high temperatures. M. E. L. DUPUY. *Ceramique,* **25,** 308–310(1922).—The strength of refrac. at high temps. was measured by means of impact, by increasing the load from zero at a rate of 150 kgs. per min. and by means of a static load. The effect of firing temps. on a clay under load was also studied. It was found (see Fig. 1) that the clay had max. strength at 1000°C

when fired to 1350°C previous to testing and at 1150°C when fired to 1500°C before testing. This clay contained Al_2O_3 = 20.0, SiO_2(free) = 45.8, SiO_2(comb.) = 26.9, Fe_2O_3 = 2.1, K_2O = 0.51, Na_2O = 0.11, and ignit. loss = 6.95. The results of the tests with different loading methods are shown in Fig. 2. and indicate that the values obtained by impact and by increasing the load from zero are about the same and that these values are about $4^1/_2$ times as great as those obtained with a static load. H. G. SCHURECHT

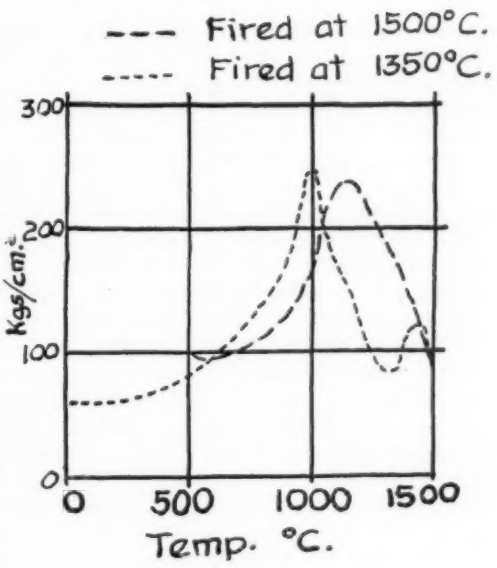


FIG. 1.

81. Carbon brick. A. P. *Deut. Töp. Ziegler Ztg.*, **53**, 219–20(1922). —The advantages of carbon brick for refrac. are: their resis. to high temps., to sudden temp. changes and their resis. to slag action. In their manuf. hard coke contg. not more than 8% ash is employed. This is crushed to 2 mm. size and mixed with 20% hot tar. The batch is thoroughly pugged and the brick are molded in wooden molds. After this they are dried about 2 or 3 weeks after which they are fired. In firing they are packed in powdered coke in a sagger or partition in a kiln and fired at cone 12. Slow cooling seems necessary as rapid cooling develops cracks. In laying carbon brick a mortar containing 20% clay and 80% coke dust is used. According to Seiger (*Stahl. u. Eisen*, **41**, 1912) carbon brick are best suited for lining blast fur. producing high carbon gray iron. It is claimed by some that they are very good for the production of Thomas iron while others state that the brick soon disappear in the production of white pig iron and Thomas iron due to their oxidation. It is evident that the value of these brick for metallurgical fur. has not been thoroughly investigated. H. G. SCHURECHT

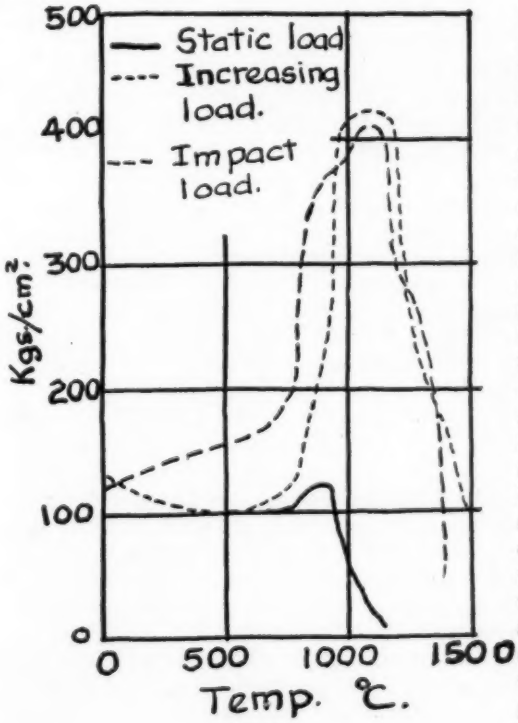


FIG. 2.

82. Electrical resistivity at high temperatures. M. L. HARTMANN, A. B. SULLIVAN AND D. E. ALLEN. *Brick Pot. Trades J.*, **30,** 16(1922).—The elec. resistivity of 9 commercial materials was detd. on $2^1/_2$-in. cubes which heated to 1500°C, the elec. resistivity being measured at intervals of 100°C. Fire-clay bricks of grade A quality and coarse texture, bauxite bricks and silica bricks with a lime bond gave regular resistivity curves. Carborundum bricks containing 95% of carbofrax C and 5% of bond gave similar curves, the resistivity being constant when the bricks were maintained at 1500°C. Carbofrax B on the contrary showed a rapid decrease in resistivity with increasing time of heating. Recrystallized carborundum ("Refrax") has quite regular curves, the resistivity being low at all temps. The resistivity curves of magnesia bricks for heating and cooling are quite different in shape, and this difference, with a peculiar flattening of the heating curves (indicating a constancy of resistance) between 1000° and 1500°C, appears to indicate that a phys. change of the structure occurs when magnesia is heated. The difference between the heating and cooling resistivity of brick made from natural zirconia is very marked. On heating the resistivity fell very rapidly until a temp. of 1200°C was reached, after which it fell very slowly indicating a permanent change on heating zirconia to 1200°C. Coarse grained chrome bricks possess low resistivities at all temps., the resistivity remaining practically constant from 1100–1200°C, increasing from 1200–1350°C and again decreasing from 1300–1500°C.

H. G. SCHURECHT

83. Bricks for malleable furnaces. H. G. SCHURECHT. *Foundry,* **50,** 707–10 (1922).—In malleable iron furnace bungs it has been found that bricks passing the usual load and softening point tests have often failed. Tentative conclusions from results, both lab. and factory, to date are: (1) burning to cone 8 gives greater resistance to spalling than burning to cone 10; (2) high load tests and fusion tests are not of first importance—good brick may or may not show high tests; (3) the spalling test seems the best guide—over 8% spalling loss (on quenching 10 times from 1350°) is dangerous; (4) bricks showing 15 to 28% porosity and 1.9 to 2.3 d. were best. SiC bricks were good but their heat cond. was too high. This could be corrected by proper insulation.

C. H. K. (*C. A.*)

84. Refractories for coke-oven construction. W. J. REES. *Fuel,* **1,** 20–2(1922); cf. *C. A.*, **16,** 2596.—The relative values of different materials for by-product coke ovens are shown by expts.: SiO_2, siliceous fire clay, semi-SiO_2 and fire-clay bricks were exposed to NaCl vapor (with and without H_2O vapor) at 800–1200°. The attack was much greater on the bricks contg. clay than on the SiO_2, the max. attack occurring with the fire clay, particularly at 900–1100°. The NaCl vapor penetrates the bricks, and the result of the slow interaction in the cooler portion and the rapid action in the hot part is to form a vesicular mass. This opens the bricks to further attack with disintegration. Expts. on a large scale, using salty coals, indicate that formation of $FeCl_3$ and NH_4Cl play an important rôle. Facing or glazing the exposed faces failed, owing to differential expansion.

C. C. D. (*C. A.*)

85. Acid electric furnace practice. CHAS. W. FRANCIS. *Iron Age,* **110,** 345–6 (1922).—The present almost universal use of acid practice in the steel foundry results from war conditions, *viz.*, scarcity of magnesite and the demand for speed. Acid practice is the fastest when ordinary specifications only are to be met. The scrap charge should be 40 to 50% foundry scrap placed on the furnace bottom and the remainder of the charge light, quick-melting, basic scrap piled in the center of the furnace where it will melt more rapidly and will not cling to side walls. No slag mixture is added as the impurities in the scrap together with washings from the lining will form sufficient slag. An acid heat should be tapped when the slag bubbles and becomes puffy, *i. e.*, a "dry" slag. For small heats the lip-pour ladle should be used rather than

a bottom-pour. Alloy additions are best made in the furnace immediately before tapping. Methods of repairing bottom and burning in a new bottom are outlined.

L. J. (*C. A.*)

86. Electric furnaces. J. H. STANSBIE. *J. Birmingham Met. Soc.*, **7,** 259(1919); *J. Inst. Metals*, **24,** 488–9(1920).—S. reviews the principles underlying the generation of elec. current and the conversion of its energy into heat in elec. furnaces. The arc, resistance, and induction types of furnaces and combinations of these types are considered. Crucible furnaces in which the resistor either is external to the crucible, which is heated by radiation, or is the crucible itself, are also described.

V. O. H. (*C. A.*)

87. Basic electric furnace operation. CHAS. W. FRANCIS. *Iron Age*, **110,** 421–2 (1922); cf. Abs. **85.**—In basic practice CaO is charged with the scrap or added after partly melting down. With an oxidizing atm. and a basic slag P is removed from the metal. More than one oxidizing slag may be necessary with high-P scrap. After complete removal of the oxidizing slag, S is removed from the bath by a deoxidizing slag (CaO and C). On account of this ready removal of S, pig iron, malleable or gray iron castings are made on a basic bottom. Removal of P cannot, however, be readily accomplished in the presence of high C. Hence in the mfg. of irons low-P scrap must be used and iron practice in general becomes a melting and recarburization process. Some modern furnaces provide high and low voltage taps on the secondary thus permitting the use of a short arc on low voltage for refining after the charge has melted down. The short arc permits better control of temp. and is less destructive to roof refractories.

L. J. (*C. A.*)

88. Principles of high temperature furnace design. E. L. SMALLEY. *Trans. Am. Electrochem. Soc.*, **42,** preprint(1922).—The best elec. ovens, judged from the viewpoints of highest quality of products, lowest cost of operation and maintenance, and greatest safety in operation at high temps., must have these attributes: Muffled type where best suited to the process. Exposed element or radiant form only when best adapted to a process. Must have elements of sufficient number for cheap renewal. Elements must be readily and easily renewable. Coils must be fully supported, and yet free for expansion. Refractory parts must be thoroughly supported, but free for expansion. No internal connections of coils should be tolerated. Terminal sizes should be larger than the element size. Source of heat must be uniformly distributed. Size of furnace must be governed by the charge. Placement of elements should not control the furnace size. Thermal efficiency should be a controlling feature in decision. Transverse section of heating elements should be round. Exposed elements should preferably be in corrugated grooves. Elements should not be chosen to suit a voltage. Total weight of heating element should be high in proportion to the weight of the charge. Efficiency of heat insulation must be adapted to the work performed. C. G. F. (*C. A.*)

89. The new electric furnace of the Fiat works. G. VITALI. *Stahl u. Eisen*, **42,** 921–4(1922).—A description of this new furnace of the Heroult type. R. S. D. (*C. A.*)

90. The new electric steel furnaces of the Fiat works, Turin. G. VITALI. *Elektrotechn. Z.*, **43,** 1177–9(1922).—7 illus. A detailed description of the Fiat furnace. The 3 graphite electrodes are each 35 cm. in diam. The new electrode holders prevent unnecessary burning away of the electrodes near the roof of the furnace. In a recent test the monthly av. was 1,341,160 kg. of steel produced at a total consumption of 937,000 kw.-hrs. which includes energy required to keep the furnace warm over Sunday and holidays. C. G. F. (*C. A.*)

91. Technical thermoelectric processes. BRUNO WAESER. *Chem.-Ztg.*, **46,** 845–7 (1922).—Elec. furnaces, the materials used in their construction and their power requirements are discussed. The ash content, sp. gr., vol. of the pores, hardness and

resistance in ohms per 1 m. length by 1 mm.^{2} cross-section of 6 kinds of C electrodes are given. The processes for the manuf. of SiC and alundum are briefly surveyed. Other thermoelec. processes will be taken up in a later paper. H. J. C. (*C. A.*)

92. Refractory cements. W. S. QUIGLEY. *Trans. Am. Foundryman's Assoc.*, **28,** 479–80(1920); *J. Inst. Metals*, **26,** 655.—Q. divides bonding materials into four classes, *viz.*—(1) fire clay; (2) coarse grades of mixed materials (so-called cements); (3) cements depending upon a fibrous structure for holding component parts together; (4) cements capable of universal application. (1) and (2) have no binding strength of themselves unless subjected to a vitrifying temp., and then only a surface bond is obtained, owing to the inability of heat to penetrate the entire thickness of the wall. The result is a vitrified shell with a weak structural backing, which frequently bulges or collapses. The third type loses its binding properties as the temp. increases. The fourth type, to be of universal application, should air-set, and its binding properties should be independent of heat. It should be passed through a fine sieve so as to obviate the formation of voids between bricks. It should be capable of being used as a binder with crushed fire brick, old crucibles, fine sand, fire clay, ganister, for making rammed-in linings, and for doing repair work (unadmixed if necessary) hot or cold. It should have as nearly as possible the same coeff. of expansion as that of the materials with which it is used as a bond. A cement with a coeff. intermediate between those of fire-clay brick and silica brick (0.075 in. and 0.175 in., resp., per ft. at 1200°) could be advantageously used with either. H. G. (*C. A.*)

93. Induction furnace for melting non-ferrous metals. ANON. *Metal Ind.*, **20,** 312–3(1922).—A new type of induction furnace for non-ferrous metals consists of a melting chamber which resembles an ordinary crucible; located beneath this melting chamber and connected with it through two parts or ducts is another chamber in the form of a hollow cylinder encircling a primary winding and one leg of a laminated core. The molten metal in this cylinder constitutes the secondary of a transformer. A positive, unidirectional circulation of molten metal between melting chamber and heating chamber (secondary) is maintained by magnetic forces. The entire lining of the furnace consists of three parts, durable and easily replaced. The furnace in starting must be primed with molten metal to fill the secondary. Continuous operation is therefore best. Power consumption has been not more than 200 kw.-hrs. per ton of brass for continuous operation. The power factor on 60 cycles is about 0.75. Metal loss is less than 1% for 60–40 yellow brass. L. J. (*C. A.*)

PATENTS

94. Electric resistance furnace adapted for heat-treating metals. I. RENNERFELT. U. S. 1,428,908, Sept. 12. (*C. A.*)

95. Electric arc furnace adapted for melting zinc. I. RENNERFELT. U. S. 1,428,909, Sept. 12. (*C. A.*)

96. Electric furnace operation in metal refining. I. RENNERFELT. U. S. 1,428,910, Sept. 12. A charge such as steel to be refined is first heated by a free-burning arc supplied with 2-phase current and the charge is thereafter heated by arcs in contact with its surface supplied with 3-phase current. (*C. A.*)

97. Electric furnace for ore reduction. W. E. F. BRADLEY. U. S. 1,427,436, Aug. 29. A rotary drum furnace discharges into a tilting elec. furnace and receives gases from the elec. furnace. The latter is provided with a C tuyère placed so as to be covered by the molten charge in the furnace during charging and reduction and uncovered when the furnace is in pouring position. The furnace is especially adapted for reducing Fe ores. (*C. A.*)

98. Electric resistance furnace for melting brass or copper. E. H. HORSTKOTTE.

U. S. 1,427,814, Sept. 5. The furnace comprizes resistance heaters made up of dished disks in elec. contact at a peripheral zone only and surrounded by a refractory shield. (*C. A.*)

99. Linings for induction furnaces. M. UNGER. U. S. 1,429,909, Sept. 19. Closed conductors of different m. p. and which may be formed of rings of ferrous metal are placed within the heating space of a furnace and melted by an induced current to cure furnace linings of MgO and tar or other materials. (*C. A.*)

100. Reducing ores in electric blast furnaces. E. FORNANDER. U. S. 1,430,971, Oct. 3. An elec. furnace is used which has a vertical reducing shaft and a laterally extending melting chamber at the base of the shaft. Ore, *e. g.*, Fe oxide ore, together with limestone and other suitable additions, is charged into the top of the shaft and after the material descends into the melting chamber it is covered with C or other reducing materials. Part of the gases evolved in the shaft are forced into the melting chamber so as to pass through the reducing material. (*C. A.*)

Abrasives

101. Corundum in India. J. C. BROWN. *Bull. of Indian Industries & Labour*, No. **12**(1922).—Corundum is widely distributed throughout India; but as yet the statistics of production are quite incomplete. Corundum is the natural oxide of aluminium Al_2O_3. Its transparent varieties which form the ruby, sapphire, and other precious stones, are not here dealt with; only the opaque, dull and semi-translucent kinds of corundum which, on account of their great hardness, are used in the arts as abrasive materials are considered in this bulletin. O. P. R. O.

102. Abrasives. J. V. LEWIS. *Mineral Ind.*, **30,** 1–8(1921).—A statistical review of natural and artificial abrasives. A. B. (*C. A.*)

Stoneware, Whiteware and Porcelain

103. Blind glazes. ANON. *Brick Pot. Trades J.*, **30,** 15(1922).—Some firms making glazed ware are troubled with a defect called "blind glazes." This defect consists in the formation of a dull glaze instead of a glossy one, the dullness being irregularly distributed over the ware so as to prevent their being passed as matt glazes. It is invariably brought about by improper treatment of the kilns as the firing comes to a close. It is very liable to occur where the glaze contains a considerable propn. of ZnO or CaO together with a small amount of Al_2O_3, and the kiln is soaked at the highest temp. too long. To prevent this, add clay to the glaze and cool more rapidly at the high temps. Since crystals do not readily form in a very fluid glaze, "blinding" may be sometimes overcome by finishing the fire about one cone higher. When lead glazes are used undue soaking periods at the high temps. are certain to cause this blinding. Firing with a reducing kiln atmos. or with a wet fuel will also cause this defect.

H. G. SCHURECHT

104. The influence of composition upon the properties of porcelain. R. RIEKE. *Ber. der Deut. Keram. Gesellshaft,* **3** [4], 187–99(1922).—Nineteen porcelains made from Zettlitzer kaolin, 40–60%, Norwegian potash feldspar, 15–35%, and Hohenbockaer sand, 15–35%, where the per cent by wt. is varied in 5% steps for each constitutent, and burned to cones 13 to 17, were tested for burning shrinkage, tensile strength, impact resistance, compressive strength between steel balls, sp. gr., and dielec. strength. Most of the values found are given at the points on the triaxial diagram corresponding to the compn. of the porc. E. N. BUNTING

105. Notes on the shivering of terra cotta. JOHN L. CARRUTHERS. *The Clay-worker,* **78,** 235–37(1922).—See *Jour. Amer. Ceram. Soc.*, **5,** 518–26(1922).

J. W. HEPPLEWHITE

106. How flower pots are manufactured. A. TAUBER. *Brick and Clay Record*, **61,** 398–401(1922).—(Translation from the German.) Discussion of requirements of finished product, selection of clays, old and modern methods of manuf.

J. W. HEPPLEWHITE

107. Factory preparation and burning of whiteware bodies. ARTHUR S. WATTS. *N. J. Ceramist*, **1** [2], 91–96(1921).—A discussion of the prepn. and burning of whiteware bodies covering briefly the following topics: raw materials; cleaning dirty ball clay; mixing the body: preparation of stain—the author recommends the following as the correct proportion: To 750 ozs. of pure water add 15 ozs. pure cobalt sulfate and stir until dissolved. Then add 7.5 ozs. carbonate of soda. The proper propns. of stain to body are: For a body contg. 10% ball clay, add 75 ozs. of stain soln. to each 1500 lbs. of body. For bodies with higher ball clay content increase the stain addn. in the same ratio up to 15% ball clay. For stain in glazes, add 10 ozs. of stain to each 100 lbs. of dry glaze. Glazes high in lead require more stain. *Sieves.*—Revolving sieves are less costly and do not clog so easily. *Filter press pressure.*—Max. pressure should be 80 lbs. for a body free from ball clay. Add 2 lbs. for every 1% of ball clay present. When the press stops running water increases the pressure 10 lbs. for a few min. *Aging and its effect.*—The temp. of clay cellars should be kept above 80°F and the relative humidity should be 90°. Aging is bad for elec. porcelain since it gives rise to gas blebs in the body. *Plasticity.*—Plastic clays are either "greasy" or "sticky." Eng. and Amer. clays differ in this respect. "Greasy" plasticity is preferable. *Pug mills.*—A slow rate of pugging produces an open body. A faster rate produces a granular, weak body. Too much speed causes the clay to heat. *Setting the kiln.*—The first and second rings should be set 1″ apart, except midway between the cuts, and the inside rings all set a like distance. Leave a 1″ opening between all rings. Not more than 6″ should be left between the top of the bungs and the crown at any point. In downdraft kilns, the center of the kiln may be set 12 to 15″ below the crown, and the burn improved if an opening is provided from top to bottom in center. *Kiln firing.*—For burning hard-fire porcelain, free from ball clay, with the body biscuited, the glost fire may progress as fast as the coal will burn, maintaining a condition bordering on reduction from the time the kiln is hot enough to develop such a condition, *i. e.*, from about the tenth hour. For best results, the fuel beds must never burn low enough to leak any air, as a highly oxidizing condition is as dangerous as a condition of extreme reduction. The temperature is dropped fast after finish to an orange red. Then close and cool slowly. By this plan it is possible to burn a 16′ kiln to cone 15 in 20 hrs. For *sanitary ware and electrical porcelain* the author gives the method of firing in considerable detail.

C. W. PARMELEE

108. The physical properties of porcelain. F. SINGER AND E. ROSENTHAL. *Ber. deut. Keram. Ges.*, **1,** 3(1920); *Sprechsaal*, **54,** 250(1921); *J. Soc. Glass Tech.*, **5,** 175–7.—Porcelain is not a homogeneous chem. or phys. substance. Each result refers only to the particular samples examd. The sp. gr. was 2.60 to 2.62, this being reduced in final burning to 2.3 to 2.5, according to the compn. The coeff. of cubic expansion varied between 0.0000045 and 0.0000065; the following were some linear expansion coeffs.: Berlin, 0.00000177 (—191 to 16°); 0.00000366 (16 to 250°); 0.000003645 (16 to 500°); 0.00000434 (16 to 1000°); Meissen, 0.00000269 (0 to 100°); Bayeux, 0.000002522 (0°), 0.000003265 (50°), 0.000004008 (100°), 0.000004305 (120°); Rosenthal lab. porcelain 352×10^{-8} and insulator H, 379×10^{-8} (20 to 100°); Seger porcelain 6833, 380×10^{-8} (20 to 100°); hard porcelain glaze 271×10^{-8}. Glaze fit depended, not only on correspondence of coeff. of expansion, but also on good elasticity, tenacity, pliability, and the resistance to stress and strain of the two components. For finished porcelain strong heating caused only a very small change of value in the thermal cond.

The mean value of the sp. heat of Berlin technical porcelain was 0.202 (20 to 200°) and 0.221 (20 to 400°). Porcelain retained heat 50 to 60 times better than iron. The heat of reaction during formation was exothermic. The modulus of elasticity for Hermsdorf porcelain gave a value of 6250 kg./mm.² detd. from the values of breaking strain of rods. Observations of the bending of circular unglazed rods gave a modulus value for Berlin porcelain of 8280 kg./mm.² Rods of Rosenthal porcelain gave values between 8400 and 17900 kg./mm.² Values of the resistance to bending shock, as detd. by the oscillating hammer, ranged, in various types of Rosenthal porcelain, from 0.08 to 2.4 cm. kg./cm.², while resistance to compressive shock, as measured by the Martens's hammer, varied from 7 to 146 cm. kg./cm.² Measurements of the hardness were obtained with any degree of regularity only by the Gary sand blast method, in which a comparison of the vols. lost under similar conditions was made. Cubic compressibility varied from 1.4×10^{-6} for highly siliceous samples to 1.8×10^{-6} for highly felspathic samples. The crushing strength showed as mean values for hard porcelain 4250 and 4780 kg./cm.²; the tensile strength for Rosenthal insulating porcelain H was fixed at 261 kg./cm.² Berlin porcelain was completely impervious to gas at 1300°, vessels composed of it had maintained a pressure difference of 30 mm. of Hg. at 100°, collapsing at higher temp. while still gas-tight. Berlin porcelain with a strong yellow color contained 0.82% of Fe_2O_3 and 0.31% of TiO_2. Small amts. of MgO, and, still more of ZnO, favored a white color. A thin sheet of porcelain was found to possess high double refraction. The sp. resistance of porcelain (after eliminating surface cond., due to grease, etc.) was high, but it fell rapidly with increase of temp. Increase of feldspar content decreased the resistance while increase of clay materials at the expense of SiO_2 added to the resistance at higher temps. The dielec. const. was 5.73, but highly felspathic, soft porcelain gave higher values. The velocity of sound in porcelain was fixed at 4900–5200 m./sec. Electrically poor porcelain had poor cond. of sound. The relationship between the cond. of sound and mech. properties was not known. H. G. (*C. A.*)

109. Electrical porcelain. A. SCHWAIGER. *Elektrotechn. Z.*, **43**, 875–80(1922).—Limiting voltages are discussed. C. G. F. (*C. A.*)

PATENT

110. Pottery; pigments. A. J. STUBBS. Brit. 181,132, March 12, 1921. Discolored earthy minerals such as kaolin, barytes, feldspar, bauxite, etc., are decolorized by suspending the finely divided minerals in H_2O to which are added pieces of Pt, Fe, or Zn. SO_2 is then introduced and is reduced by catalytic action to hyposulfurous acid, liberating O, which renders the coloring substances sol. in the hyposulfurous solvent. The coloring substances can be pptd. by CaO or an alkali for use as pigments. The SO_2 may be prepd. by the action of H_2SO_4 on metallic Cu. (*C. A.*)

Art and Design

111. Yellow etching compound. L. SPRINGER. *Sprechsaal*, **54**, 212, 225(1921); *J. Soc. Glass Tech.*, **5**, 61–2.—This substance is obtained by mixing Ag compds. with yellow ocher and grinding intimately with water or oil. The intensity of color produced varies with the Ag content of the compd. (except in the case of the sulfide, which is stated to give a deeper color) with the temp. of burning in, and with the nature of the glass decorated. Opinions vary as to the effect of the glass on the depth of color produced. Zsigmondy, by the use of Ag phosphate, concludes that the color is caused by the reduction of Ag compds. which enter the glass, the action being due to impurities such as C, S, FeO, or metallic Pb. In this case, glasses free from impurities would not be affected. S. has made two similar alk.-lime glasses, one with potash, the other with soda, both decolorized with Ni oxide and Se. When these are treated with the

etching compd. under the same conditions, the potash glass is scarcely colored, while the soda glass becomes fairly bright yellow. Careful mixing and application of the mixt. are found to eliminate the dirty, uneven effect usually obtained in the treatment of certain weakly colored window glasses and of carbon-yellow glasses. A very hard, highly siliceous soda-lime glass is observed to be very little affected by the etching compd., even when heated until it softened. To est. the proportion of Ag which enters the glass, the residue of a Ag chloride-ocher mixt. (25 : 100) is treated, after burning, with NH_3, and the Ag chloride is then re-pptd. Only about 20% of the Ag is recovered.

H. G. (*C. A.*)

Heavy Clay Products

112. Handling the finished products of industry. GRAHAM L. MONTGOMERY. *Chem. & Met. Eng.*, **27**, 731–3(1922).—The handling of brick in manuf. by mechanical handling equipment is a simple problem, because of uniformity and size of product. Why modern methods have not been used. Suggests methods based on experience of American Enameled Brick and Tile Co., in use of conveying equipment. Number of brick handled in a given time has been increased 20%. R. R. DANIELSON

113. The making and marketing of common brick. J. B. ROSE. *N. J. Ceramist*, **1** [3], 198(1921).—Presented at a meeting of the N. Y. Building Congress. Existing conditions in the trade are attributed to ignorance, lack of sympathetic coöperation and half-season work. 40% of the labor employed in the Hudson River district comes from the south. It is suggested that a commission should be appointed to make a survey and full report regarding the requirements of the market for the year. The rules of the Board of Education in N. Y. City prescribe that no brick may be laid when the thermometer shows a temp. below 32°F. The author objects to this restriction. There is need for a law guaranteeing the producer and the supplier of materials compensation for such when furnished for building purposes. The author is of the opinion that there is sufficient clay along the Hudson Valley to meet all the future requirements of the Metropolitan district. The supply of sand for the purpose is limited.

C. W. PARMELEE

114. The properties of some ball clays. H. H. SORTWELL. *The Ceramist*, **2** [1], 5–15(1922).—Some of the results of an investigation of domestic and foreign ball clays conducted by the Bureau of Standards. *Miscellaneous properties of ball clays.*—(See Table I.) The oxidation test was conducted by the means of draw trials 2 x $1^1/_4$ x $1^1/_4$, and heated to 750° in 5 hrs., and held at that point. American clays contain less material coarser than 120-mesh than English clays. The average moduli of rupture were:

Kentucky clays	282 pounds per sq. in.
Tennessee clays	366 pounds per sq. in.
Devonshire clays	443 pounds per sq. in.
Dorset clays	405 pounds per sq. in.
English clays (source unknown)	419 pounds per sq. in.

The clays were divided into three classes according to their color—Class 1, the best; Class 3, the poorest. Graphs show the burning conduct of the clays. English clays vitrified at low temp. and remained almost constant in porosity and volume to cone 12, without signs of overfiring. Amer. clays showed gradual reduction in porosity from cone 01 to cone 12 and constantly changing volume. With one exception they did not vitrify before cone 12. Tenn. clays vitrified before Ky. clays. Comparisons of color were made on test pieces of a standard body mixt.

TABLE I.—MISCELLANEOUS PROPERTIES OF BALL CLAYS

Lab. No.	Name of Clay	Water of plasticity	Vol. drying shr.	Shr. water	Pore water	Ratio pore water–shr. water	Density dried clay	Residue on 120-mesh	Hrs. oxidation at 750°C	Mod. of rupture, 1 clay-1 flint
1	Knowles Eng. Ball Clay, No. 1	45.6	28.4	24.3	21.3	0.88	1.667	0.2	0.5	376
2	Knowles Eng. Ball Clay, No. 2	51.9	26.1	24.7	27.2	1.10	1.413	1.5	11.0	375
3	Knowles Eng. Ball Clay, No. 12	44.9	27.7	23.9	21.0	0.88	1.627	0.7	9.5	568
4	Whiteway Eng. Ball Clay	39.9	28.4	22.3	17.5	0.78	1.738	0.4	8.5	446
5	Eng. Ball Clay, No. 90	47.3	29.6	26.3	21.0	0.80	1.627	0.7	8.0	441
6	Pikes Ball Clay	46.3	32.2	27.9	18.4	0.66	1.742	0.2	4.5	381
7	Superior Ball Clay	46.4	28.2	24.6	21.8	0.89	1.598	1.2	11.0	563
8	Kentucky Ball Clay No. 4	46.7	28.1	24.7	21.8	0.88	1.593	0.1	3.5	372
9	Tenn. Ball Clay, No. 5	51.9	29.2	26.5	25.4	0.96	1.537	0.4	8.5	478
10	No. 25 Blue Ball Clay	48.3	33.5	29.5	18.8	0.64	1.712	0.9	2.5	403
11	Devon Ball Clay	44.3	26.5	21.9	21.4	0.98	1.652	0.4	2.0	345
12	Tenn. Ball Clay, No. 11	44.5	26.0	21.9	22.5	1.02	1.585	0.1	1.0	293
13	Dorset Ball Clay	45.9	33.0	28.1	17.8	0.64	1.753	0.1	1.0	492
14	Kentucky Ball Clay, No. 10	38.3	25.5	19.7	18.6	0.94	1.733	0.0	0.0	223
15	Eng. Ball Clay, No. 11	48.5	33.5	29.2	19.3	0.66	1.723	0.3	1.5	396
16	Fayles Ball Clay	47.0	32.7	28.3	18.7	0.66	1.714	0.8	2.0	347
17	Grindley Ball Clay	45.8	29.1	25.3	20.5	0.81	1.623	0.8	10.0	427
18	Great Beam Ball Clay	47.6	28.8	25.6	22.0	0.86	1.577	1.6	8.5	454
19	Kentucky Ball Clay, No. 9	41.5	27.0	22.1	19.4	0.88	1.671	0.0	0.0	253
20	Tenn. Ball Clay, No. 3	53.3	27.6	29.9	23.4	0.78	1.545	0.3	2.0	327
22	M. & M. Eng. Ball Clay	45.8	28.9	24.7	21.1	0.86	1.587	1.4	7.5	384

TABLE II.—COLORING EFFECT OF CLAYS IN STANDARD BODY

No.	Name of clay	Color of body	Class
1	Knowles Eng. Ball Clay No. 1	Very light buff	2
2	Knowles Eng. Ball Clay No. 2	White	1
3	Knowles Eng. Ball Clay No. 12	Light cream	1
4	Whiteway Eng. Ball Clay	Buff	3
5	English Ball Clay No. 90	Light buff	2
6	Pikes Ball Clay	Cream	2
7	Superior Ball Clay	Light buff	2
8	Kentucky Ball Clay No. 4	Cream	2
9	Tennessee Ball Clay No. 5	Light cream	1
10	No. 25 Blue Ball Clay	Light buff	3
11	Devon Ball Clay	Light buff	2
12	Tennessee Ball Clay No. 11	White	1
13	Dorset Ball Clay	Buff	3
14	Kentucky Ball Clay No. 10	Light buff	3
15	Eng. Ball Clay No. 11	Buff	3
16	Fayles Ball Clay	Buff	3
17	Grindley Ball Clay	Light buff	3
18	Great Beam Ball Clay	White	1
19	Kentucky Ball Clay No. 9	Light cream	1
20	Tennessee Ball Clay No. 3	Cream	2
22	M. & M. Eng. Ball Clay	Cream	2

(See Table II.) Class 1 includes those of the best color; Class 2, fair color; Class 3 poor color. American clays showed a good color. Tenn. clays were better color than Ky. The majority of Devonshire clays were in the second class; three of the four Dorset clays were in Class 3. American clays nearly equal the English in plasticity, they require more exact firing because of the variations in porosity and vol., with slight changes in ht. treatment, which is the reason for the difficulty observed in attempts to substitute Amer. for English clays. The more porous body obtained by substitution of Amer. clays is conducive to crazing. Successful substitution requires a little higher firing or readjustment of the flux content to produce the same degree of vitrification.

C. W. PARMELEE

115. Working wet lime clays. W. D. RICHARDSON. *The Clayworker*, **78**, 336–7 (1922).—Method of removing limestone pebbles in entirety described, then a résumé of results of various experiments is given as regards fineness of grinding, the temp. at which the ware is burned and the duration of the high fire to prevent mechanical destruction and pitting of burned ware. J. W. HEPPLEWHITE

116. The manufacture of silica-lime bricks. ANON. *Science et industrie* [March, 1922]; *Industrie chimique*, **9**, 360(1922).—Nearly all sands even those with 10–15% clay, are suitable. In the slaked lime process of manuf. the moistened mixt. is pressed and baked in autoclaves under a pressure of 8–10 kg. per sq. cm. A. P.-C. (*C. A.*)

Glass

117. Nuts in glass. ANON. *Glass Container*, **1** [12], 5–31(1922).—Descriptive article tracing the development of merchandising and extension of demand by packing nuts in glass containers. WM. M. CLARK

118. Bottle blowers "tip" builds park highway out of glass mountain. ANON. *Glass Container*, **1** [12], 11–26(1922).—For building a road in the Yellowstone National Park it was desirable to remove material from Obsidian Cliff, a mountain of natural glass. Powerful explosives were ineffectual in blasting away the mass. One of the engineers (a former glass blower) suggested heating the mountain and then spraying the mass with water to cause it to disintegrate. Log fires were maintained for $^3/_4$ mile along the base of the mountain for several days and then water was sprayed on and a tremendous explosion followed which loosened the entire face of the mountain and cleared the way for the road, also later the chunks of glass were found admirably adapted for road-building. WM. M. CLARK

119. The binary systems Na_2Sio_3–Na_2WO_4, K_2SiO_3–K_2WO_4 and Na_2WO_4–K_2WO_4. J. A. M. VAN LIEMPT. *Z. Anorg. Chem.*, **122**, 175(1922).—The binary system Na_2WO_4–Na_2SiO_4 has been investigated by Van Kloster (*Z. Anorg. Chem.* **69**, 154(1911)), who found that the fused salts were mutually soluble to a high degree. The present paper deals with viscosity and specific conductivity measurements of aqueous solns. of these salts to det. whether compds. were formed therein. No evidence of compd. formation was found in the series Na_2SiO_3–Na_2WO_4 or K_2SiO_3–K_2WO_4. E. W. TILLOTSON

120. Melting of glass. ANON. *Jour. Soc. Glass Tech.*, **6**, 3–17(1922).—General discussion at the Leeds Meeting, November 15, 1921. **Casing of opal on flint glass.**—The importance of exactitude and speed in covering the ball of flint with a uniform layer of the opal, and of having the two glasses match in expansion was pointed out (M. W. TRAVERS). With a softer covering glass, less accurate matching is required (W. E. S. TURNER). **Frequency of charging of batch into furnaces.**—It was agreed that *feeding of tank furnaces* at short intervals, 10 to 30 min., gave better quality of glass and meant a saving of fuel, provided the use of a dog house eliminated periodic cooling. With an open furnace and no bridge, large fillings seem to be better (J. ADAMSON). R. L. Frink prefers to add a charge of about one-fourth cullet and then to fill the batch

on top. In the case of *pot furnaces*, best results are obtained if the pot is filled with three successive equal charges (R. L. FRINK). **Influence of saltcake on decolorizing action of selenium.**—W. E. S. TURNER stated that while 1 to 2% produced no serious effect, laboratory experiments for 1 to 5 per cent showed that the decolorizing effect was certainly diminished. R. L. Frink has found that 1 to 2 per cent stabilized the color as well as being otherwise advantageous. The final color of the selenium glass depends also on the leering. **Dark spots in chromium green glass** are due to undissolved chromium oxide (J. H. DAVIDSON). They may be prevented by grinding the oxide fine or by mixing it with two parts of bichromate (F. G. CLARK). **Causes of secondary boil.**—This boil may be produced in a variety of ways, such as by a smoky gas flame depositing carbon on the surface (M. ASQUITH), by too great changes of temperature either cooling or heating after melting, by iron dropped in the glass, by the oxidation of carbon and sulphur coloring material, and by decomposition of small amounts of salt-cake (W. E. S. TURNER). **Action of various analytical reagents on chemical glassware.** W. E. S. TURNER AND T. E. WILSON. *Jour. Soc. Glass Tech.*, **6,** 17–20(1922).—In continuation of previous researches, four glasses were tested with nitric acid (sp. gr. 1.2), 2 N-ammonium sulphide solution and sodium phosphate solutions (N/2 and N/4). For the first two solns. the loss in 90 min. at 100°C was only 3 to 5 mg. per 100 cm.², but the corrosion by the phosphate solution was somewhat greater, increasing with the concentration. This action seems not to be due merely to alkalinity, since one of the glasses is relatively much more corroded by the phosphate solutions and by 2 N-sodium carbonate solution than by N/10-caustic soda.

G. S. FULCHER

121. Polohalite. ANON. *Raw Materials Rev.*, **1,** 43(1922).—A mineral of great utility to the glass industry and for soap-making has been found in the valley of the Morelle River, Sicily. A dip has disclosed: Saline marle contg. gypsum, chloride of sodium 2 m., sulphates of various bases 14 m., sulphate and chloride of sodium 4 m., other sulphates of various bases, marle and gypsum in great masses. O. P. R. O.

122. Autoclave test for chemical glassware. GAILLIE AND WILSON. *Jour. Soc. Chem. Ind.* (London), **40,** 448R(1921).—Results from this test show a closer relationship between the degree of clouding and the amount of alkalinity. There was a considerable measure of concordance between the results obtained with the autoclave test and those obtained with the dimming test. There was a close relationship between the durability hardness and alumina content of these glasses. This investigation of the autoclave test was made primarily to test durability. O. P. R. O.

123. Glass discovery. ANON. *London Times Trade & Eng. Supp.*, **11,** 31(1922.)—The manuf. of glass and glassware is one of the oldest-established industries of Czecho-Slovakia. The new discovery is that of a silicate which is suitable for the production of raw glass without the aid of other ingredients. The mineral is of volcanic origin and as the deposits are very extensive they should provide the Czecho-Slovak glass industry with a cheap raw material. O. P. R. O.

124. Glass manufacture in Burma. ANON. *London Times Trade & Eng. Supp.*, **11,** 29(1922).—Burma possesses large quantities of raw materials for glassware. Despite the difficulties which face a pioneer industry of a highly technical kind, a native Burman has made such successful expts. that Burma has an established glass industry in the vicinity of Rangoon. O. P. R. O.

125. Glass powder. ANON. *Raw Materials Rev.*, **1,** 88(1922).—By rubbing the walls of a vessel with a glass rod, small particles of glass are rubbed off, which act as crystn. centers or coagulators. If the rubbing is continued for a time a deposit is obtained even in distilled water, meriting the attention of chemists. One can thus obtain glass

in suspension in the most various soln., the resistance of which by the addition of various substances can be increased, and small quantities of glass powder can be collected.

O. P. R. O.

126. Ruby glass. ANON. *Schnurpfeil's Rev. for Glass Works*, **6** [66], 1311(1922.)—Copper ruby is one of the hardest colors to make and control. A simple batch is manganese with saltpeter or manganese in an opal base batch. In an opal batch use 2.5 MnO_2 for 100 of sand. The following batch colors out on reheating, sand 100, soda ash 40, borax 8, zinc oxide 10 to 12, selenium 1.25, cadmium sulphide 1.75. If zinc powder is used it will color in the furnace. Sulphur gives a fair ruby. Copper ruby is usually used in cased glass. The following batch colors out on annealing. Sand 100, soda ash 35, lead oxide 5, borax 3, lime 10, barytes 8, bone ash 0.5, red tartar 4, oxide of tin, 3, cuprous oxide 1.5. Phosphoric acid and barytes often aid coloring.

R. J. MONTGOMERY

127. Annealing and heat treatment of gauge glass. HENRY W. HESS. *Glass Worker*, **41** [53], 11(1922).—Gauge glass subject to sudden temp. changes should be uniformly strained and not well annealed. If local strain is introduced by cutting off or fusing the ends it may be made uniform by heating to about 1300°F and cooling rapidly and evenly in air.

R. J. MONTGOMERY

128. To tarnish or etch glass surfaces. MARCEL AND ANDRÉ FICHTER. *Glass Worker*, **42** [5], 15(1922).—A French patent by M. and A. Fichter increases the working life of a hydrofluoric acid bath to 3 or 5 weeks and reduces the emission of vapor to almost nothing. Two baths are mixed separately and then put together in any propn. desired, as follows. Bath 1, + fluoride of sodium 5 gr., water 5 gr., sulphate of potash 1 gr.; bath 2, + chloride of zinc 2 gr., hydrochloric acid 3.5 gr., water 4.5 gr. Use the same as the old type of bath.

R. J. MONTGOMERY

129. Natural constants and technical constants of glasses. E. ZSCHIMMER. *Z. Elektrochem*, **28,** 194–201(1922).—A lecture. Values of a no. of different consts. for various kinds of glass are compared and discussed.

H. J. C. (*C. A.*)

130. The necessity for preheating air in furnace work. A. POPOFF. *Sprechsaal*, **54,** 496(1921).—A theoretical consideration of fuel saving by preheating the air used in a glass tank furnace.

H. G. (*C. A.*)

131. Rubbing of glass walls with a glass rod. ROBERT FRICKE. *Z. Elektrochem.*, **28,** 244–5(1922).—Crystn. is promoted by rubbing the glass walls of a vessel with a glass rod, not by mech. shock as is often stated in text-books, but by the production of a fine glass powder the particles of which act as crystn. nuclei.

H. J. C. (*C. A.*)

132. Comment on R. Fricke's communication "Rubbing the wall of a glass vessel with a glass rod." L. DEDE. *Z. Elektrochem.*, **28,** 364–5(1922); cf. preceding Abs.—It is claimed that the formation of crystals takes place more readily when the walls of a glass vessel are rubbed with a rubber-covered rod instead of a glass rod, and that the formation of crystals is probably due to electrostatic causes. Reply. R. FRICKE. *Ibid.*, 365–6.

H. J. C. (*C. A.*)

133. Optical glass. Its properties and production. J. W. FRENCH. *Optician*, **59,** 335, 351; **60,** 3, 18, 28(1920); *J. Soc. Glass Tech.*, **5,** 112–3.—A brief account is given of the history of glass from the earliest times. The optical properties of glass are considered at length, the loss of light due to various causes playing a large part in the production of optical instruments. Important defects in optical glass are lack of isotropy and homogeneity, the former due to insufficient annealing and the latter to veins and striæ. The striæ are avoidable by finely grinding the batch constituents and thoroughly mixing them, and by keeping the fluid glass well stirred. Veins due to the solvent action of the glass on the pot and stirrer can best be minimized by suitably choosing the clays from which these are made. The devitrification of glass is fully

discussed. A curve shows the increase in durability of a soda-lime-silica series of glasses due to the increase of lime content. Glasses contg. less than 6% of lime are unstable on account of their defective durability, while if the percentage is greater than 17 (the silica content remaining at 70%) they are impracticable owing to melting difficulties and opalescence due to devitrification. A similar curve illustrates the decrease in durability of a series of flint glasses as the lead content increases. The building and drying of the pots are described and a short account is given of glass works furnaces. This is followed by a description of the actual melting process, special attention being directed to stirring. The molding into small pieces, inspection for defects, and annealing operations are briefly described. H. G. (*C. A.*)

134. Dispersion formulas and the secondary spectrum. T. SMITH. *Trans. Optical Soc.*, **22**, 99(1920–21); *J. Soc. Glass Tech.*, **5**, 181–2.—From a study of the n's of many glasses the data being derived from the Jena glass lists, S. empirically deduces a formula by means of which n for any wave length, λ, can be calcd. from the relative dispersions. For a "normal" glass this formula is $n - n_D = [0.226(n_F - n_C) + 0.0062 (n_D - 1)] (\lambda^{-0.91} - \lambda^{-0.91}_D)/(\lambda^{-0.91}_F - \lambda^{-0.91}_C) + [0.774(n_F - n_C) - 0.0062(n_D - 1)]\text{-}(\lambda^{-3.4} - \lambda^{-3.4}_D)/(\lambda^{-3.4}_F - \lambda^{-3.4}_C)$. When a glass is not "normal" the actual n differs from that obtained by the formula. For wave lengths between C and F the correction is negligible, being of the order of 2×10^{-5}. In the case of the ends of the spectrum, the glasses which have to be corrected are more numerous and the corrections larger. Even here, however, few glasses have corrections larger than $\pm 6 \times 10^{-5}$. The formula, which differs only slightly from one previously advanced by Conrady, is further confirmed by application to Gifford's results. The bearing of the formula on the secondary spectrum of thin lenses was discussed. H. G. (*C. A.*)

135. Abrasives and polishing powders for glass. JAMES W. FRENCH. *J. Oil Colour Chem. Assoc.*, **5**, 103–110(1922).—A review of the principles of abrasion and polishing, with photomicrographs of etched percussion cracks and scratches in polished glass, and of abrasives and polishing mediums. That polished glass consists of an amorphous surface layer, covering innumerable scratches which etching develops through removal of this surface layer, does not seem to be correct. The polishing process on glass consists of wearing away all parts of the surface to a common level, and not of the formation of an amorphous surface layer which bridges over cavities, as seems to be the case in certain polished metals studied by Beilby (*C. A.* **8**, 3750). Discussion. F. A. W. (*C. A.*)

136. Heat losses in glass manufacture and their control. KLAFTEN. *Sprechsaal*, **54**, 251(1921); *J. Soc. Glass Tech.*, **5**, 140.—K. divides heat losses into 3 sections. The first section includes losses which are inevitable, such as heat used in the producer to convert solid to gaseous fuel, heat taken away by the ash, and heat lost by gas waste during reversal. In this class also are placed losses occurring at working and other openings in the furnaces. The second group contains losses which can be obviated or reduced, such as those caused by bad regulation of the producer (entailing premature burning of the gas or loss of unburnt fuel in the ash), and losses at poking holes where not carefully constructed. This section also includes heat losses caused by incomplete burning of the gas in the furnaces, due to incorrect air supply or to faulty design of burners, chambers, or flues. Another source of loss, the conduction and radiation of heat, can be minimized by the use of suitable insulating materials. In the third section are grouped losses which are not recoverable in one direction, but which can be made use of in other ways. Among these are included the use of heat from the generator for drying moist fuel, of heat from the waste gases for drying fuel or heating the room, and finally, of the use of heat lost by the furnace crown to warm the blast or secondary air. The following figures for the heat balance of a plant are given. Of every 100 cal. of

heat supplied 95.5 came from the producer and 4.5 from the steam. Useful heat for melting glass amounts to 12.5 cal., while 12 are recovered from waste gases. The heat losses are 15 cal. in the producer, 4 in the flues, 0.5 during reversal, 6 in the regenerators, 20 by conduction and radiation from the substructure, and 23 from the superstructure, 7 lost in chimney waste gases and radiation from the brickwork.

H. G. (*C. A.*)

137. The structure of abraded glass surfaces. F. W. PRESTON. *Trans. Optical Soc.*, **23,** 141–64(1922); *Naturwissenschaften*, **10,** 517–9.—A study of the physics of ground and polished glass surfaces. The object is to substitute the conception of a flaw or fissure complex for the current view of a hill and hollow structure. The enhanced soly. of ground surfaces in HF is shown, and from this soly. is estd. the thickness of the flowed or surface tension layer. The grains of abrasive are dragged over the surface, producing chatter and diamond cuts, percussion flaws, cascade cuts and intermediate forms. The hills and hollows do not represent the full depth of fractured layer, for below is 2–3 times the depth of flaws. French (*Trans. Optical Soc.*, Nov., 1916) contended that there is a flowed (*"beta"*) layer approx. 8 wave lengths deep. By etching with HF and detg. the rate of soln. for the surface layer and for that below the crit. depth, P. attempted to confirm or disprove this. A comparison of a disk-cut surface with a grayed surface showed that HF attacked the former only 0.3 as fast as the latter. A grayed surface was attacked 11 times as quickly as a polished one. The rapidity of HF attack on a grayed surface quickly decreased, becoming the same as that on a polished one. The rate of attack on the polished surface remained const. It is concluded that if there is a *"beta"* layer 8 λ deep, it does not differ in soly. from the massive *"alpha"* material. The high initial rates on grayed surfaces can be due either to a surface area 10–12 times that of the polished apparent surface or to the surface material differing radically from the massive. From the Twyman effect it is shown that the surface is under excessive strain. It is, therefore, judged that both effects are present, an increased area due to chatter-flaws and an enhanced soly. due to strain. It is shown by etch patterns that there is a detail of a few millionths of an in., and this could not exist in a flawed surface tension layer. So if glass has a flowed layer it is only 2–3 millionths in. thick. Feldspar and quartz were much more resistant to HF than glass. The structure of glass was developed in 15 sec. in 2 *N* HF at 15°, whereas feldspar required 5 min. and quartz 7 min. with 5 *N* HF. Etching of apatite and fluorite with H_2SO_4 suggested a certain plasticity of their crystals. C. C. D. (*C. A.*)

138. Grease for molds. ANON. *Sprechsaal*, **54,** 6, 67(1921); *J. Soc. Glass Tech.*, **5,** 103–4.—The following formulas for grease for molds in which goblets are blown give a high brilliancy to the glass, and also resist dislodgment by water into which the mold is dipped. (1) A mixt. of very finely ground pure charcoal with resin is spread over the mold by a gathering of hot glass. (2) The mold is warmed and coated, not too thickly, with linseed oil or thick varnish. Charcoal, very finely ground and sieved (preferably through coarse canvas), is then uniformly spread over by a sieve. (3) Equal parts of varnish and resin are melted together for 1–2 hrs. and, on cooling, a third of red lead is added. After coating the mold evenly and spreading with fine charcoal, it is heated in the furnace or allowed to stand for $2^1/_2$ hrs. H. G. (*C. A.*)

139. The chromate-albumin copying process as an etching basis for glass, etc. C. FLECK. *Sprechsaal*, **54,** 340(1921); *J. Soc. Glass Tech.*, **5,** 126–7.—The soln. for coating the glass consists of: distd. water, 1000 cc.; NH_3 (sp. gr. 0.960), 20 cc.; albumin, 50 g.; $(NH_4)_2Cr_2O_7$, 7 g. The results are satisfactory only when distd. water is used. For the prepn. of the soln., the best method is to dissolve the albumin in 275 cc. of water, beat up, and run in the soln. of dichromate in the rest of the water, shaking together, and then filtering carefully through a cotton-wool wad. The plate to be etched is cleaned

by rubbing with the following mixt.: sieved whiting or powd. charcoal, 20 g.; NaOH, 2 g.; water, 50 cc alc., 50 cc. After cleaning and washing off all solid grains from both sides of the plate, the clean surface is covered with the albumin soln., excess being drained off. Drying is performed in an app. for rotation over a hot iron plate; care is needed not to prolong the heating unduly, otherwise coagulation of the albumin results. The pattern is printed on the prepd. plate from the negative in a copying frame, time of exposure being one to two min. in summer sunlight, two to three min. in the winter sun, and ten times as long in diffused light (too great exposure hardens the prepn. and prevents the absorption of color). The colors applied are generally printing colors, often thinned down with lavender oil. Such a color can be made as follows: rectified turpentine, 50 cc.; powd. Syrian asphalt, 10 g.; good illustration color, 40 g. The above can be melted together and filtered into a box or bottle. Colors which contain wax or tallow do not give sharp copies, and, if applied to designs with fine, close lines, they give a confused result on burning in. The color is applied by evenly rolling into the plate, and the pattern then developed by laying the plate in water and washing with a soft sponge or pad, using a rotatory motion. After washing with water, the plate is dried in the app. for rotation and fine asphalt powder is shaken over it; the surface is dusted with a wad, freed from the last traces of dust with talc and a powder puff, and the design burnt in. Everything outside the copy is covered with shellac, which was dried. Finally, the design is etched with a strong etching soln., so that, after etching, little color distinction remains, and a relief is obtained which can be felt when rubbed over.

H. G. (*C. A.*)

140. Modern glass factory equipment. W. S. MAYERS. *Glass Ind.*, **3**, 197–9 1922.—A discussion of the *fan system of air cooling*. J. B. P. (*C. A.*)

PATENTS

141. Furnace. F. O'NEILL. Brit. Pat. 179,977, Jan. 12, 1921. Ill. Off. Jour. Pats., July 12, 1922. Describes arrangement for delivering uniform charges of molten glass from a tank furnace. Sketches of mech. details. WM. M. CLARK

142. Crucible furnaces for manufacturing glass. KOSUKE HIRANO. Japan, 39,936, Sept. 14, 1921. Addition to 35,365. Diagrammatical description. (*C. A.*)

143. Apparatus for testing glass containers. O. C. K. HUTCHINSON. U. S. 1,427,817, Sept. 5. Glass bottles or the like are carried on a conveyor between electrodes which subject them to a spark to detect pin holes or cracks. (*C. A.*)

Enamel

144. Standardization of enameled apparatus for chemical purposes. EMERSON P. POSTE. *Chem. & Met. Eng.*, **27**, 1016–19(1922).—A paper presented at 8th Chem. Exposition, on Ceramic Day, Sept. 15, 1922. Describes standardization as regards types of enamels to withstand varying degrees of corrosive action, materials of construction, uses, and methods of temp. control on app. R. R. DANIELSON

145. Growth of cast iron. (From report by TARIO KIKUTA, *Jap. Iron & Steel Inst.*) *Chem. & Met.*, **27**, 510(1922).—Growth of cast iron in heating is attributed to two different causes; (1) internal oxidation, (2) expansion of occluded gases. K. measured the leakage of gases through a gray cast iron tube at room temp. and at 960°C. Leakage at high temp. was only slightly less. It is therefore improbable that air enters at low temp. and cannot escape at high temp. Tests in vacuo show that growth is not due to oxidation. K. concludes that growth is due to decomposition of cementite and to formation of minute fissures caused by differential expansion of various micro portions.

R. R. D.

PATENT

146. Enameling. L. DE RAPHÉLIS-SOISSAN. Brit. 982,788, July 3, 1922. To support and fix the enamel powder on metal the articles are coated with a porous non-carbonizing substance such as asbestos, mica, pumice stone, or infusorial earth, in powder, fiber, or sheet form, and the enamel is painted thereon or may be previously incorporated therewith. The articles are then shaped and fired. (*C. A.*)

Cement, Lime and Plaster

147. Gypsum withstands fire. ANON. *Contract Record*, **36,** 961(1922).—Expts. at Chatham, Ontario, Canada, demonstrated the effectiveness of gypsum as a fire resisting material. A building was erected by the Ontario Gypsum Co., at Chatham, with gypsum board on wood studding; this was filled with dry hay, wood, oil and other combustible materials and set on fire. The heat was terrific but the fire was allowed to follow its own course and after it died away a stream of water from a fire hose was turned upon it. Outside of being blackened and stained by smoke, the house was uninjured and examination showed that the studding and frame work beneath the gypsum board were uncharred and in as good condition as when first erected.

O. P. R. O.

148. Lime bricks. HENRI SERVANGE. *Raw Materials Rev.*, **1,** 88(1922). France claims to have produced lime-bricks from raw chalk of limestone waste and clay or sand, by mixing sand or clay in any propn. with chalk and pressing the product wet. The pressed goods are heated in a brick kiln to an easy red glow, 500° to 550° C, which corresponds to the temp. of the decompn. of slaked lime. At the same time the atm. in the kiln is kept moist by forcing steam into it, in order to obviate the complete desiccation of the bricks. The too rapid escape of the carbonic acid must be prevented by the use of proper slides, as its presence is indispensable for hardening the monocalcium-hydrosilicate. After a few hours of this treatment, the bricks will have become exceedingly hard when they can be removed from the kiln. O. P. R. O.

149. Structural materials tested. HYDRO-ELEC. POWER COMM. OF ONTARIO. *Annual Report*, p. 275, 1921–22.—The activities of the structural materials lab. may be classified into 3 divisions: cement testing; concrete testing; and testing of miscellaneous structural materials. To this might be added coöperative activities in conjunction with national organizations, such as the Canadian Eng. Standards Assoc., in carrying out technical investigations and in the preparations of specifications. A considerable decrease in the cost of testing and inspection is the result of the research work carried on in the laboratory of the Hydro-Electric Power Commission. O. P. R. O.

150. Fuel and cement kilns. ANON. *Times Trade Supp.* (London), **11,** 19 (1922).—The research into rotary kilns for cement burning made by the British Portland Cement Assoc. on a £ to £ grant from the Dept. has given results that are already incorporated in the practice of cement works, and show a saving of 4 to 5% of coal and an increased output of ten per cent of cement. One firm alone is saving £25,000 a year in its fuel bill as it was before the Armistice. O. P. R. O.

151. New system of concrete construction. ANON. *Canadian Engineer*, **43,** 413(1922).—Concrete houses are now being constructed in Gr. Br. by a new method known as the "Wilkielock," system which consists of making the outer walls of clinker concrete slabs, $2^1/_4$" thick, faced with $^3/_4$" cement mortar, a $4^1/_2$" space being left, while the inner slabs are made of coke breeze and cement, also $2^1/_4$" thick. The result, it is stated, is that warmth is obtained without condensation. O. P. R. O.

152. Anhydrite as building material. ANON. *Raw Materials Rev.*, **1,** 180(1922).—"Chemiker Aeitung" states that the large beds of anhydrite in the Hartz could be utilized

by grinding the decomposed product with small additions of 3.5% of lime, and the result would be a building material that could be used for walls, ceilings, floors, and artificial stone, etc. Like any gypsum, it must not be exposed to continuous wet without protection. The tests of the Prussian Geol. Land Bur. also confirm the applicability of anhydrite. O. P. R. O.

153. Sand-lime bricks. H. O. WELLER. *Dept. of Scientific & Industrial Research.* Building Research Board. London (1921).—"Mortar bricks" were made by an Englishman above 80 years ago; they were a mixture of sand and lime, hardened in the air; which process took from 6 to 18 months, developing a very small amount of calcium silicate. As a result of subsequent improvements Michaelis of Berlin took out his master-patents for true sand-lime (calcium-silicate) brick 40 years ago; his process, modified, is now exclusively used. Any clean siliceous sand, from quarry, pit or river, may be used; many other refractory and waste materials or by-products, such as slag, clinker, shale, quarry-waste, shards, etc., are suitable. The only other necessary material is lime. O. P. R. O.

154. Thermochemistry of (cement) vertical kilns. J. B. *Rev. Mat. Constr. Trav. Pub.*, **156,** 169–172(1922).—In burning materials for cement the following reactions take place, (*a*) fuel is burned to give CO_2, H_2O and SO_2. (*b*) carbonates of calcium and magnesium are decomposed to their oxides and CO_2. (*c*) in some calcareous materials org. matter and sulphur burn. (*d*) lime reacts with silica and alumina, the mass undergoing incipient fusion. It is known that reactions (*a*) and (*c*) produce heat, and that (*b*) absorbs heat. Berthelot and Le Chatelier maintain that reaction (*d*) is exothermic, while Timm states that it is slightly endothermic, and Stanger and Blount that the evolution of heat is practically negligible. A numerical example is given accounting for all the heat put into the furnace, heat absorbed and heat lost.

LOUIS NAVIAS

155. Gyratory crushers. G. C. *Rev. Mat. Constr. Trav. Pub.*, **156,** 175–9(1922). —A tech. description of the parts of the "Atlas" gyratory crusher. (With 4 cuts.)

LOUIS NAVIAS

156. Effects of alkali on concrete in prairie provinces. T. THORVALDSON. *Contract Record*, **36,** 953(1922).—The problem of the so-called action of alkali on concrete is generally considered to be peculiar to the prairie provinces of Canada and the corresponding States in U. S. The result of the low rainfall and poor drainage is the cause for presence in the soil of a large amount of sol. salts. Analyses of waters from the 3 provinces show that the dissolved salts are, in general, mainly sodium, magnesium, and calcium sulphates, with occasionally a large quantity of common salt. Until lately all failures of concrete were attributed to defects in the cement or concrete. Failures of some concrete structures exposed to sea water were considered by some as due to the salts. Of late it has been the general opinion in Great Britain that well-made constructions of dense concrete will stand up indefinitely when immersed in the sea but well-made concrete manufd. from the best materials will not stand up long if in contact with certain ground waters. Experiments on the preparation of concrete using water containing a high concentration of alkali salts indicate that the early development of strength through hydration is not interfered with. Cement briquettes will develop nearly full strength when cured in sulphate solutions of a concentration which later causes disintegration. Thus the alkali disintegration seems to be so slow in its action that the effect on the fairly rapid process of hydration is not noticeable. It is, therefore, likely that the action of the alkali is on the products of hydration of the chemical compounds in cement clinker. The free lime produced during the hydration of the calcium silicates in the cement has a slight solubility in water. On account of the low solubility and the consequent tendency to attain equilibrium in a thin film of

liquid on the surface, the extraction of hydrated lime from cement by pure water is slow. However, fair-sized crystals of hydrated lime may form on the surface of briquettes stored in distilled water. This leaching out of hydrated lime progresses most rapidly in the case of cements high in tricalcium silicate, while cements in which dicalcium silicate largely predominates are not so active. This statement holds in practice for specimens of equal permeability to water, and since dicalcium silicate after setting is much more porous than tricalcium silicate this advantage of the lower silicate disappears in practice. If bicarbonates or carbonates are present in the water these react with the hydrated lime forming insoluble calcium carbonate which may form a protection against further removal of lime and a partial protection against the action of sulphates from the outside. However, this protection is usually quite inefficient, at best, delaying the sulphate action somewhat. When sulphates are present in the water, in contact with the concrete, the conditions are entirely changed. The calcium of the hydrated lime reacts with the sulphate radical and calcium sulphate is formed. The solubility product for this substance is low, and the presence of a large concentration of the sulphate ion will therefore render it almost insoluble. It separates out of solution as the hydrated form of gypsum. The removal of the calcium from solution in this manner upsets the equilibrium between the dissolved and solid hydrated lime and speeds up the leaching out of this substance from the cement, while the moment it enters solution the calcium continues to be precipitated as gypsum. If the sulphate present is sodium sulphate, the liquid attains caustic alkalinity, while the sulphate disappears as gypsum into the solid phase. On the other hand, if magnesium salts are present as well as the sulphate, the hydroxyl ion is removed neutral, while both the magnesium and the sulphate radicals disappear from the solution and enter the solid phase. Thus the presence of dissolved magnesium salts and sulphates in water which is in contact with cement or concrete, produces ideal conditions for the constant removal of lime from the lime silicates in the cement, with the consequent weakening of the concrete and when carried to completion final loss of all cementing properties. The theory that the disintegration is due to the physical forces exerted during the crystallization of gypsum in the voids in the concrete can hardly stand as a sole explanation. It, no doubt, contributes to the final results by causing fissures in the weakened concrete and thus facilitating the access of the harmful sulphate waters to the interior portions of the concrete. At present the only remedy known is the manuf. of concrete of low permeability and high strength and this is only an expedient for lengthening the life of the structure.

O. P. R. O.

157. Fundamental physical and chemical properties of commercial lime. I. The available lime content. M. E. HOLMES AND G. J. FINK. *Chem. Met. Eng.*, **27**, 347–9 (1922).—Quick-lime and hydrated lime are defined and the line of investigation to be followed in the series of papers on this subject indicated. Titrametric methods of detg. the available CaO are described and the available CaO % on non-volatile basis is shown to equal: (% available CaO in samples as used)/(100 — loss on ignition). Tables show the available CaO content of typical Ca quicklimes in their corresponding hydrates and similar data on typical Mg limes. The tables emphasize a great variation in the available CaO content. The tendency is to have a higher available lime content than the corresponding hydrates as detd. by the A. S. T. M. method. Data show that it is possible to hydrate so as greatly to minimize this tendency. Reduction in the available CaO content during mech. hydration and mech. treatment may be due to mod. aggregation whereby a portion of the CaO is rendered physically unavailable or due to mole transformation by local burning during hydration converting some of the CaO into a less sol. form. The state of moisture and local temps. in the hydrator may cause chem. reactions tending to produce a small percentage of an insol. product

W. H. R. (*C. A.*)

158. Thermal conductivity of white marble and "Neat" cement. ROY A. NELSON. *Phys. Rev.*, **18,** 113–5(1921).—Thermal conductivity of "Alabama White" marble and of "Neat" cement was measured by the cylinder method at the following temps.: 50° to 100°, 100° to 150° and 150° to 200°. For marble the values 0.00614, 0.00524, and 0.00415 and for "Neat" cement 0.0014, 0.00165, and 0.00146 were obtained. The marble was principally $CaCO_3$ with a small amount of $MgCO_3$. The "Neat" cement was made of Portland cement and water. D. MACR. (*C. A.*)

159. Heat efficiency increase in cement burning. H. LARMOUR AND W. C. STEVENSON. *Concrete* (Cement Mill Section), **19,** 95–6(1921).—L. and S. submit the design of a proposed preheating bin for raw mixts. The bin is placed at the upper end of the cement kiln and all raw mix entering the kiln receives a preliminary heating in the bin, from the kiln gases on their way to the stack. The bin is fitted with 36 vertical tubes, 16 ft. long and 10 in. in diam. Such an installation should increase the output of the kiln, recover some of the dust ordinarily lost, and reduce the fuel cost per barrel of cement by 24%. J. C. W. (*C. A.*)

160. Kiln efficiency discussed. C. O. SANDSTRUM. *Concrete* (Cement Mill Section), **20,** 48–9(1922).—**Heat efficiency increase in cement burning.** C. E. BURGOON. *Ibid.*, 77.—Discussions of the paper by Larmour and Stevenson (cf. preceding abstr.). J. C. W. (*C. A.*)

161. The measurement of the temperature of rotary cement kilns. R. NACKEN AND G. SCHOPPE. *Zement*, **10,** 581–4, 595–7(1921); *Chimie et industrie*, **7,** 1149(1922).—The temps. were measured by means of Pt-Rh couples placed at 6-m. intervals in the shell of a 60 m. by 3 m. kiln. The results are plotted with the revolutions of the kiln as abscissas and the temps. observed at 60° intervals as ordinates. At 10 m. from the mouth of the kiln the av. temp. of the material was 50°. At 24 m. there is already a difference between the temp. of the clinker (K) and that of the gases (G). If the kiln is turning counter-clockwise, the max. temp. for each revolution is at a point 60° to the left of the lowest point, while the min. is at points 60–120° to the right of the lowest point. The av. temps. are $K = 350°$ and $G = 450°$. At 37 m. $K = 930°$, $G = 1060°$. The dissociation of $CaCO_3$ is hardly beginning, as it takes place at a higher temp. in an atm. rich in CO_2. At 45 m. $K = 969°$, $G = 1290°$. The lower value of K is due to the decompn. of $CaCO_3$, which requires 42.5 cal. per kg.-mol. of $CaCO_3$. At 48 m., *i. e.*, 3 m. back of the zone where the lime is burned, $K = 1255°$, $G = 1295°$. At 50 m. they are 1310° and 1345°, resp. G reaches a max. of 1430° at a distance of 52 m., but G does not rise as much (1360°) owing to the absorption of heat by the partial fusion of the clinker. At 54 m. G falls to 1410° while K remains practically the same. The burning is almost complete at a distance of 56 m. A. P.-C. (*C. A.*)

162. Defects in the manufacture of Portland cement, and their causes. A. HEISER. *Tonind. Ztg.*, **46,** 63–4, 79–81(1922); *Chimie et industrie*, **8,** 613(1922).—In one instance, owing to a leak in the H_2SO_4 app., CO_2 escaped, and deficiency of $CaCO_3$ was found. An excess of $CaCO_3$ was added, which gave an expansive cement. Another plant using the dry process and a rotary kiln turned out expansive cement owing to an excess of 1% of $CaCO_3$. In the case of a cement which set in barely 15 mins., the addition of 1% of plaster made it set in several hours. With respect to the spontaneous transformation of slow-setting into quick-setting cement, H. advizes mixing slow-setting cement in silos contg. large quantities of cement whilch have already undergone the transformation; also, increase the lime content, thoroughly moisten the clinker, add the max. amt. of plaster, and do not grind too fine. All the above mentioned cases of expansion were due to the presence of free lime. A. P.-C. (*C. A.*)

163. Cement industry in China. J. M. CLEMENTS. *Concrete* (Cement Mill Section), **21,** 44–7(1922).—An account is given of the 5 cement plants in China. J. C. W. (*C. A.*)

164. Increasing the resistance of cement to sea water by the addition of trass. A. HAMBLOCH. *Zement*, **11**, 53–4(1922); *Chimie et industrie*, **8**, 614(1922).—Grün (*Ceram. Abs.*, **1** [8], 219) advises the addn. of pulverized sand instead of trass (to blast-furnace-slag cements) as the sand would give the same results and cost less than the trass. There are other factors which affect the compactness of the cements exposed to the action of sea water, and more particularly colloidal action, which is entirely lacking in sand. Moreover, trass has a chem. action in the hardening of concrete owing to the combination of the Al_2O_3, the CaO and the alkalies with the sol. SiO_2 under the action of the hydrosilicates, which action is comparable to the zeolitic phenomena observed in nature.
A. P.-C. (*C. A.*)

165. Change in volume of Portland cement and of concrete. ANON. *Zement*, **11**, 27–9(1922); *Chimie et industrie*, **8**, 613(1922).—The av. heat expansion coeff. of concrete is 0.00055% per degree F. Its expansion under the action of moisture may be 100 to 500 times as great. When a bar of cement is taken out of water it gradually contracts for 60 days. When put back in water it undergoes considerable expansion during the first week, and much less during the following weeks; the total elongation is 0.15%. Neat-cement bars were observed during 6 years. During the last years they were subjected to 4 periods of moistening and desiccation; the same variations occurred each time, and at the end of 6 yrs. the elongation was 0.08% greater than at the end of 3 yrs. the expansion and contraction can be regulated by adjusting the conditions of moistening and desiccation. These facts are explained by Michaelis' colloidal theory of the setting of cements. To test the effects of atm. humidity, the cement bars, after complete drying, were subjected at room temp. to an atm. satd. with moisture. After 3 months' expansion was 0.10%. Analogous expts. with hot water gave practically the same results as cold water.
A. P.-C. (*C. A.*)

166. Utilization of waste heat from rotary cement kilns. JOSEPH BROBSTON. *Mech. Eng.*, **44**, 517–8(1922).—Examples are given of waste heat boilers installed in cement plants, showing a reduction from 30 to 40% of the coal consumption.
L. A. P. (*C. A.*)

167. The testing of trass. ANON. *Tonind. Ztg.*, **46**, 90–2(1922); *Chimie et industrie*, **8**, 614(1922).—"Trass" is defined as finely ground waste from volcanic tuff quarries, of such nature that when mixed with $Ca(OH)_2$ it can set either in air or under water. The official German specifications and methods of testing are given.
A. P.-C. (*C. A.*)

168. The dispersoid chemistry of gypsum. II. Research on anhydrite. H. NEUGEBAUER. *Kolloid-Z.*, **31**, 40–5(1922).—There are 3 forms of water-free $CaSO_4$; estrich gypsum formed by drying at 800° (it will set in water), dead-burned gypsum, and sol. anhydrite. The 3rd variety is formed by heating at about 100° under atm. pressure. It always contains as much as 4% of water. The rate of hydration of these forms was tested by measuring the viscosity of 3% suspensions at short intervals. Some com. prepns. of anhydrite show a rapid increase in viscosity indicating rapid hydration.
F. E. B. (*C. A.*)

169. High-strength cements. JEAN HENDRICKX. *Chimie et industrie*, **8**, 296–304 (1922).—The quality of artificial cement depends mainly on its physico-chem. compn., burning and cooling, and fineness of grinding. H. proposed (*Le Ciment*, 1920) the following compn. formula: $x SiO_2.2.5CaO + y Al_2O_3.3CaO + z Fe_2O_3.3CaO$ (by wt., not equivs.), and $SiO_2/(Al_2O_3 + Fe_2O_3) < 2.5$ and > 1.8. The latter is called the "SiO_2 modulus." By using more CaO than is given by the max. of the formula there is no great increase in strength, but danger of swelling. By using less than the min. the strength falls off. The following method (*Le Ciment*, 1920) is proposed for detg. the "burning quality." One g. of the mixt. is partially burned under standard conditions,

and the residue insol. in acids and alkalies is detd. with a compn. agreeing with the above formula, if the residue does not exceed 7.5% the "burning quality" is satisfactory. A lower limit (generally about 6%) can be readily fixed when SiO_2 must be added to raise the SiO_2 modulus. In order to det. if possible the reason of abnormally high strengths which are occasionally encountered, H. undertook a series of researches comprising: (1) chem. and spectroscopic analyses; (2) petrographic investigation of crystn. and clinkering; (3) physical tests in connection with fineness of grinding. Considerable work remains to be done, but some interesting results have already been obtained. (1) No trace of Be could be detected, but Ti is probably present. (2) Examn. of thin sections of two samples taken from the same batch of fused aluminous cement which had been differently cooled seems to show that this cement is a mixt. of silicates and aluminates and does not consist of aluminates crystd. in an Fe silicate as was believed at first. The examn. of 6 samples taken from a kiln under different conditions of burning and cooling showed that slow burning gives as good results as quick burning, provided that in the first case the clinker is cooled in water, while in the second case it should be cooled slowly. Two kinds of crystals are distinctly visible under the microscope, polarizing and non-polarizing; the latter seem to be more important as far as quick setting and high initial strength are concerned. (3) The amt. of residue which does not pass a standard sieve is not a criterion of the abs. fineness. The method and time of grinding and the sp. hardness of the material affect the abs. fineness, even when the sieve test gives the same results. The wt. of a 1. of the pulverized material, as generally detd. in the lab., decreases rapidly with the degree of fineness, while the sp. gr. as detd. by the LeChatelier-Candlot volumenometer remains practically const. The ratio (sp. gr.)/(wt. per 1.) is called the "modulus of fineness" and is used as a measure of abs. fineness. Tests carried out on 100 samples ground in a small Alsing mill and having practically all the same residue on a 4,900 mesh (presumably per $cm.^2$) sieve, and on 50 samples ground industrially, showed that the higher the modulus of fineness the better the quality of the cement, that with a modulus below 2.6 cements with high initial strength cannot be normally obtained, and that the modulus of fineness does not have the same effect on all cements, thus showing the importance of the crystalline form. A. P.-C. (*C. A.*)

BOOK REVIEWS

NOTE.—Under this heading we will give analytical reviews of those books which will be practical additions to the library of the manufacturer, practical potter, ceramic decorator and student. A publisher's announcement rarely describes a work from a pottery man's point of view, and as a result it is no simple task for the latter to select and find just those books which will furnish essential data (if such exists) covering some phase of his particular activity. If a book is of general interest only, or if it specializes on some particular type or branch of the work, such facts will be presented for the consideration of those interested.

Creative Impulse in Industry. HELEN MAROT. E. P. Dutton Company. 3rd. printing. 1919. $1.50.

A survey of industrial conditions made for the Bureau of Educational Experiments. Apparently written during the War with the intent to find a way not only to increase industrial efficiency in this country, but to do this with the interested coöperation of the workers.

The author's point of view is at once apparent in the following abstracted statement:

"All productive force is artificially sustained which is not dependent on men's desire to do creative work."

If there is a business in the United States that needs increased efficiency, it is that of the clay worker, and any sincere and authoritative attempt to show how this can be

done should surely be investigated. The manufacturers in the clay industries will read this book with mixed feelings, because it is probably the strongest indictment of the prevalent organization attitude towards the workers, that has yet been written.

The progressive organization official has followed the researches of Taylor and other efficiency engineers and has, as far as conditions will allow, adopted policies which at least prove their superiority over the previous grossly inefficient custom (for it cannot be called a system), where ignorant, incapable, disinterested and unreliable persons are put in charge of important industrial activities and placed in positions of authority over large numbers of people.

But, however much the human interest may be lacking in an organization, a system which will result in doubling production without an increase in cost is twice as efficient as the system that it superseded. This much must be accepted or one cannot read Miss Marot's book without a feeling of impatience and, finally, resentment.

Frederick W. Taylor has at least succeeded in convincing the large manufacturer of the importance of efficient shop operation, and it may be added that this was not done by means of literary reviews, but by years of active demonstration in some of the largest industries in this country.

If Taylor's "Principles of Scientific Management" and Miss Marot's book were side by side in a book store and superficially examined by an interested executive, we know which one he would purchase and carry away. It would not be "Creative Impulse in Industry." But this does not mean that this book is less valuable than Taylor's, or that it should not be in the possession of everyone concerned with production of every character.

Few industrial authorities will disagree with Miss Marot's conclusions. In fact, they are already accepted by a number of large manufacturers. Everybody knows that an interested worker is likely to be more efficient than a disinterested worker, and that an organization of interested workers is infinitely more productive than a disorganized, disgruntled organization. For obvious reasons, even the most conservative manufacturers are giving some attention to the social, educational and industrial conditions among the working classes as they exist today. But there are so many inimical conditions to a rational and business-like program as presented by Miss Marot, that it is quite definite that from twenty-five to thirty years will elapse before any educational movement in the direction of increased efficiency is generally tolerated.

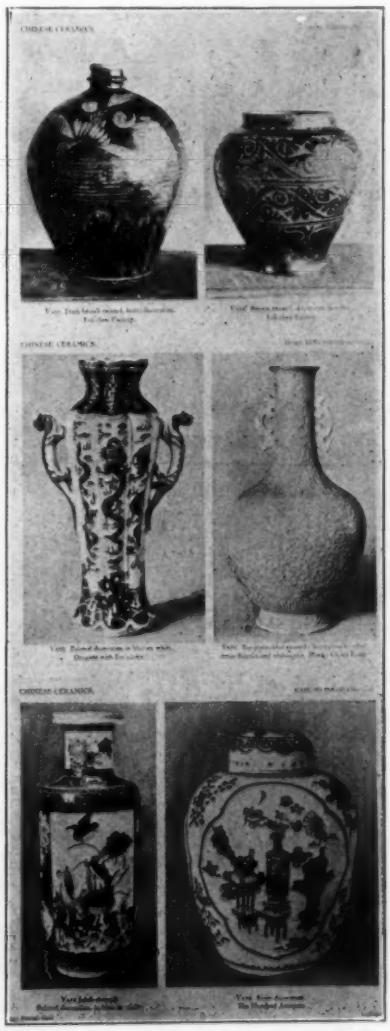
The Unions will fight to the last ditch any activity that tends towards either making the worker satisfied or interested in his job. The workman must be discontented and he must be inefficient, or he cannot be a Union member in good standing. It is only necessary to take notice of the present sanitary ware strike. Here is a case where the unions compel the worker to limit the production to the point where anything like a reasonable productive efficiency is impossible. Various authorities agree that we must give speedy attention to the problems of industrial training. In fact, we are already doing this. But as stated, it will be at least two generations before we will have a condition where the labor element of the country is interested enough in creative or productive effort to have the desire to be efficient. However, there is no doubt that such books as this will contribute to bring about such a desirable condition.

Chinese Ceramics. J. J. MARQUET DE VASSELOT AND M. J. BALLOT. (Published by Albert Morance. Paris. 1922.) Brentano's, New York. 2 vol., $18.50.

Two compact folios, 9″ x 7″, containing eighty odd lithographic reproductions of Chinese vases in the Louvre Museum. Most of the plates are in color. The first volume deals with the Han-Ming periods (206 B. C. to 1643), and the second follows the K'ang Hsi, Yung Cheng, and Ch'ien Lung periods and on to the present day (1662 to 1911).

Interesting and authoritative historical reviews accompany each volume. There are also reproductions of marks, and a short list of works of reference.

While the most noticeable omissions in this collection are those of examples of some of the finer figures of the Han period, and the monochromes of the K'ang Hsi period, the collection as shown is fairly representative, and the work as a whole is a notable addition to existing works on Chinese ceramics.



The first volume is particularly interesting, and the plates of the Ming polychrome figures and vases are beautifully reproduced.

The value of such a work as a reference for the American collector is obvious, but it possesses yet far more practical value for the manufacturer of art wares, the modeler, the ceramic engineer and decorator.

PLATE LXIX.

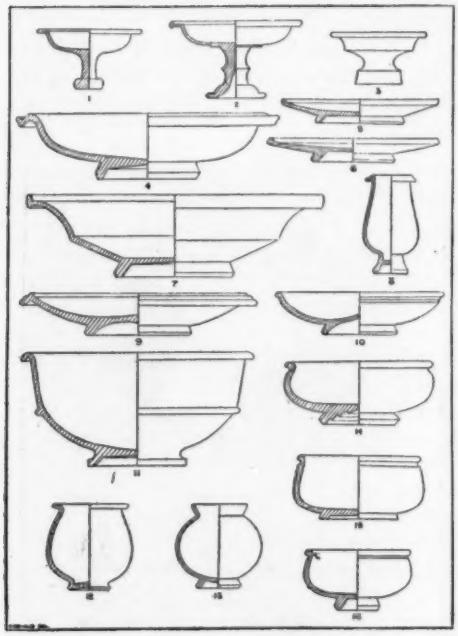


PLATE XXVIII

An Introduction to the Study of Terra Sigillata. FELIX OSWALD AND T. DAVIES PRYCE. Published by Longmans, Green and Co., New York City. 1920. $16.50.

A profusely illustrated study of the "Terra Sigillata" or more commonly known "Samain" ware.

A general description of the Italian Sigillata (Arretine Ware), and the provincial Sigillata is given, and the various developments are chronologically treated.

There is quite a complete bibliography, and the eighty-five carefully drawn plates show some fifteen hundred ceramic forms and decorative details.

The book is a comprehensive and scholarly archaeological study, and it will find its place in the various libraries as such. But we are concerned with its value to the potter, for here is a wealth of material and information such as the art potter, terra cotta and faience manufacturer have been looking for, for many a day.

There is page after page showing decorative treatments, motifs, and shapes developed during the various periods in which these were produced. The latter part of the work is devoted almost entirely to shape construction drawings which will be particularly valuable as references for the shape designer and modeler. Many of the decorations are typically terra-cotta treatments, and as such, the book should be received with great interest by the architectural ware people.

F. H. RHEAD

Laboratory Manual of Colloid Chemistry. HARRY N. HOLMES, Professor of Chemistry in Oberlin College. John Wiley and Sons, Inc., New York; Chapman and Hall, Limited, London, 1922. xii+127 pp., 32 figs. 23.5 x 15 cm.

It was at the suggestion of the Colloid Committee of the National Research Council that this most excellent manual was written by Dr. Holmes and this committee deserves much credit in the selection of the author. The subject matter is taken up under the following sixteen chapter headings: Suspension; Dialysis and Diffusion; Condensation Methods of Preparation; Dispersion Methods of Preparation; Coagulation; Protective Colloids; Solvated Colloids; Surface Tension; Emulsions; Viscosity; Adsorption from Solution; Adsorption of Gases; Reaction in Gels; Experiments with the Ultramicroscope; Soils and Clays; Special Topics. There are in all 186 experiments carefully selected to illustrate the principles involved and accompanied by short discussions of the theory, in which many references are made to the current literature, The manual also contains a short but excellent bibliography. It is so written that it is admirably suited for use in supervised laboratory courses in colloid chemistry and at the same time equally serviceable for those who desire independently to become more familiar with this subject. Lists of experiments for the following special courses are given: A General Course; A Course for Medical Students; A Course for Students of Ceramics and Agriculture; A Course for Students of Geology; and A Course for Students of Industrial Chemistry. The book is well written and has already proved to be a valuable addition to the Colloid Chemical literature. W. G. FRANCE

Henley's Twentieth Century Formulas, Recipes and Processes. Edited by Gardner D. Hiscox, M.E., The Norman W. Henley Publishing Co., New York City. 1922. $4.00.

Containing over seven hundred pages of formulas, recipes and processes for the workshop and practical man. Acid-proofing, Adhesives, Alloys, Aluminum and its treatment, Amalgams, Bronzing, Brass Casting, Celluloid, Cements, Dyes, Enameling Explosives, Glass, Inks, Jewelers' Formulas, Lacquers, Lubricants, Photography, Plating, Rust Preventives, Soaps, Solders, Artificial Stone, Varnishes, Waterproofing, Wax, are only a few subjects selected at random. The technical man will smile during his perusal of the ten pages of old-fashioned (but reliable) formulas under the heading of ceramics, but this will not prevent the book from being what is claimed for it; "a useful reference work for the mechanic, manufacturer, artisan and the general home worker."

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BULLETIN

of the

American Ceramic Society

A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical and Scientific Questions and Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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EDITORIAL

WHAT SERVICE SHOULD BE RENDERED BY THE AMERICAN CERAMIC SOCIETY IN 1923

When the American Ceramic Society engaged a secretary for full-time service it was done that the Society could more effectively serve the Ceramic Industries. Only a limited number of the proposed lines of activities could be followed through as fully as had been planned, but with the larger experience and with the more efficient organization a larger service in 1923 is not only possible, but is essential.

The three new Divisions: Art, Heavy Clay Products and Whitewares, are now well under way with definite purposes and well-working organizations.

The *Journal* has been enlarged, the world's literature abstracted more thoroughly and more discussions of papers and topics developed, and the *Bulletin* instituted. Some of our friends have been so kind as to tell us that the *Journal* is a live, inspiring report of research activities.

The Divisions, the Local Sections, the Committees, the Board of Trustees and the *Journal*, it seems to us, should be the means to the ends for which the Society was organized and chartered: To promote the ceramic arts and sciences.

How can the ceramic arts and sciences be most effectively promoted? This is the query in answer to which we shall direct our efforts during this year.

Mr. A. V. Bleininger outlined a program of activities in September, 1921, which seems to us to be well worth adopting for 1923. If those to whom his recommendation makes an appeal will collaborate with the executives and committees there is no reason why a considerable portion, if not all of this program, can not be realized.

1. The work of certain committees should be pushed very vigorously immediately. I am referring particularly to the Committee on Standards. No more important work could be undertaken than the standardization, through specifications, of the principal raw materials, such as flint, feldspar, ball clays, sagger clays, etc. Certain misconceptions as to the functions of these materials cause a continuous loss which could be readily stopped. A modern classification of clays, based entirely upon their physical properties, is urgently needed.

2. Steps should be taken also to compile the information already available for use. A large amount of data is scattered through our *Transactions* and various *Journals* which should be brought together in the form of a handbook, like the "Sprechsaal Kalender," but much larger, more complete and better all around. The book might be divided into two parts, one dealing with general information and the other with specific industries. The former could be prepared by assigning different subjects to men well qualified to handle them. The industrial topics could be turned over to the Divisions who would be best qualified to include the material most valuable and to arrange it in the best manner.

3. Research organization is desirable. The only point is that we must not overdo this kind of work. The industries have never yet failed to produce any kind of a product, which may be needed in any quantity, quite different from some of the purely chemical industries and the need for research is not as acute as it is with them.

4. The great need of the industries is for trade schools, in which the young clay workers of the country may be trained for their work and for advancement. As it is, the thousands of young men engaged in factory work have no opportunities, and the places to which they aspire are taken by college trained men having no previous connection with the industries. The need is imperative for schools like those at Stoke-on-Trent, Sèvres, Bunzlau, Hoehr, Teplitz, etc., where through afternoon and evening classes the young men are given an opportunity to really learn the fundamentals of their trade, which is not done in the present status of the apprentice system, and in addition be given the technical principles of the manufacturing processes. This could be worked out in several of the leading ceramic centers in connection with the High Schools, supplemented by workshops and laboratories made available through coöperation on the part of the manufacturers. There is no reason whatever why one or two such schools, in addition to the one at Trenton, could not be established, and the SOCIETY could do no better work than to lend its influence towards this end. The trade schools of Germany have played an important part in the industrial development of that country

and we also can no longer neglect our industrial population. It must be given opportunities not only from the standpoint of industrial training, but also from that of citizenship and higher aspirations. We must do our part to help raise our people from the deadly mediocre level to a higher one.

5. The preceding paragraph is not intended in any way to prejudice the cause of collegiate education in this field. But with the development of trade schools, the level of accomplishment on the part of the college trained man must undoubtedly be raised. The need along these lines is not number of graduates but quality of training, and even now it would seem that the four years' course is hardly adequate, and it might become necessary to insist upon a five years' course or one of four years with summer studies. The danger of overcrowding the field with a large number of indifferently trained graduates is very real, and we should not encourage the example set by the colleges as regards technical training in general. The country has been flooded with poorly trained men for whom there are not sufficient places in normal times. We are not desirous to create a technical proletariat.

I believe it would be well if the SOCIETY gave some attention to ceramic education and could counsel the schools in connection with the general problem and such details as might come up for consideration.

PAPERS AND DISCUSSIONS

DISCUSSION ON "THE RELATIVE MERIT OF HEAT RESISTING ALLOYS FOR ENAMEL BURNING RACK"[1]

By I. F. Cox:—The data presented by Mr. Poste are of particular interest, not only from the standpoint of the user of enameled products, but of all furnace users, as metals play an important part in the construction of most furnaces.

The composition of the furnace atmosphere, the fuel used in firing, and other furnace conditions will have a considerable effect on the degree of oxidation of metal parts. This is of course a function also of temperature, and this temperature would have to be known quite accurately to obtain any strictly comparable results. For instance, in the matter of calorized steel, we recommend it only for intermittent service above 1700°F, for continous service at or below that temperature. Experience in a variety of applications has indicated that the dead line is perhaps sharper than one would think.

In connection with the place occupied by calorized steel in this list, it would be of interest to know the kind of steel to which the calorizing had been applied, and whether this was effected by the dipping or powder process. Judging from the data in Table I, it is probably a piece of rolled steel, as a piece of calorized steel will have a slightly higher resistance to warpage (as measured by this test) than the same piece of steel uncalorized. A piece of cast steel, calorized, would occupy a higher position in Table I, and the same position it now occupies in Table II.

The accurate determination of the relative resisting power of various metals is very difficult to determine from laboratory data, principally because it is quite difficult to exactly reproduce the commercial conditions under which these metals are to be used. The "order of magnitude" can so be determined, and thus an indication given of what metals are worth trying out on a commercial scale. Where possible, it is highly desirable to subject several sets of the test pieces to commercial conditions. On the basis of results obtained from such a test, or from laboratory tests, the next logical step is the trial of one or two commercial sized pieces under operating conditions, of these alloys which look most promising. It is interesting to note that two alloys mentioned in Mr. Manson's discussion of Mr. Poste's paper, occupy a different relative position at 2000°F, than they do in Mr. Poste's experiments at 1700°F. This indicates further, the desirability of subjecting the test to actual commercial conditions, wherever possible.

Mr. Poste has well pointed out the necessity of considering the various conditions to be met—the relative importance of warpage, oxidation, etc., and the consideration of the whole matter on the basis of relative

[1] *Jour. Amer. Ceram. Soc.*, **5** [11], 811 (1922).

cost. In figuring costs on this basis, there must often be taken into consideration the matter of cost of replacing and lost production during the time required for replacement.

CALORIZING CO.
PITTSBURGH, PA.

NOTE ON "THE DISINTEGRATION OF SODA LIME GLASS IN WATER"

BY J. C. WITT:—In a paper on the above subject by Arthur E. Williams[1] it is stated that when soda lime glass has been treated in water at temperatures below boiling, at boiling point, and up to 25 pounds pressure in an autoclave, disintegration results—*i. e.*, cracks, spalls and loss in weight. This is a very interesting paper and reminds me of some failure of glass fruit jars in this laboratory.

We have not been carrying on any research on glass, but in connection with some of our work we have filled glass fruit jars with water or solutions, covered the top with a rubber membrane and then placed them in water in a larger cylinder where they were subjected to a hydrostatic pressure of 500 pounds per square inch for periods ranging from several days to several months.

None of these jars broke in service, nor did they break immediately after removing from the pressure cylinder. However, it has been observed that a number of these jars have cracked several weeks after the pressure treatment. In the first instances it was taken for granted that the jars had been cracked as a result of moving them around the laboratory but so many cases have been observed that it is now known that this is not the case.

In the light of the paper by Mr. Williams, it seems that the glass may have been attacked to some extent by the water under pressure, although they were not subjected to anything above room temperature. A possible explanation is that they were weakened by this treatment, then at some later time became cracked due to slight changes of temperature in the laboratory.

REPLY BY A. E. WILLIAMS:—The occurrence noted by Mr. Witt regarding the spontaneous breakage of glass articles has come to my attention a number of times. This has especially been noted with large vessels used for show purposes or for the storage of organic specimens, which have given way spontaneously after a year or more of standing filled with liquids, usually alcohol or salt solution. The more resistant soda-lime glass now generally made would probably never exhibit any such breakage, the cause of which may possibly be explained as a release of stresses in the surface film, due to solution lowering the tensile strength of the article as a whole.

[1] *Jour. Amer. Ceram. Soc.*, **5** [8], 504–17 (1922).

PRESIDENT'S PAGE

DR. ORTON TO INDUCT 1923 OFFICERS INTO OFFICE

All of the older members of the SOCIETY who have attended any of the earlier conventions will remember how Dr. Orton introduced the new officers to the members. Everybody felt that it was a privilege to be there and the officers themselves felt that the honors they were receiving were even greater than they had previously considered them to be. After the officers had been installed, the group of two or three who had been selected to be promoted to active membership were formally presented to the SOCIETY and made to feel that the promotion was not only an honor but that they deserved this recognition as a compensation for the loyalty they had shown the SOCIETY as well as for their contributions.

It is a pleasure to announce that Dr. Orton has written accepting our invitation to induct the 1923 officers into office at the banquet at the annual meeting in Pittsburgh.

We deem it an honor to have him with us at our Silver Jubilee Meeting and are sure that his presence will be of interest and so appreciated by the older members that they will arrange to attend the meeting.

REPRESENTATION OF DIVISIONS ON THE BOARD

The November *Bulletin* announced a proposed amendment to the Constitution[1] which was introduced at the meeting held at the Chemical Exposition by Messrs. Staley, Sweely and eight other members. This amendment was later withdrawn with the understanding that it would again be brought up by the Rules Committee after some alterations had been made in the methods of election and terms of office of the various members.

The important point about the amendment is that it provides that the Board of Trustees will include as a member a trustee from each Division, each trustee to be chosen by the particular division which he represents. This is a step towards decentralized control and should receive the hearty support of all. The present method of having three trustees besides the officers and two past presidents, and having these men chosen at random regardless of division connections, has worked well in the past but is not adequate for our present needs.

The three most important points to consider in the procedure for the accomplishment of this are the method of election by the division members, the term of office, and the schedule for the year of installation of trustees from each Division, so that the entire board will not go out of office at once. This provision for an overlapping of terms of office of the various trustees is the most important point to consider. It is hoped that the Rules Committee will be in position to present the proposed amendments at the February meeting and that they will receive everybody's hearty support.

[1] *Bull. Am. Ceram. Soc.*, **1** [11], 321(1922).

ACTIVITIES OF THE SOCIETY

OH, SHOOT!

Whether the season's sport is rabbit hunting or African golf, the record of the past two months is not to be sneezed at by those who have been taking a rest since the football team disbanded. Evidently a law has been passed prohibiting the bagging of more than one Corporation Member by an individual, and in eight weeks we have only five to show, but the smaller game has been plentiful and fifty-two specimens are ranged in the Secretary's office. W. E. Lemley has proved himself an all-round sportsman and heads the list. Ira Sproat reached up a little way into the sky and pulled down a big bird with one hand and a little one with the other. W. E. Dornbach and M. Ichiyo each came in with two, and thirty-six hunters have one apiece. C. L. Sebring, Geo. S. Tillotson, and A. Weber, Jr., are responsible for the big game. The score card follows:

	Personal	Corporation		Personal	Corporation
W. E. Lemley	4		F. A. Kirkpatrick	1	
Ira E. Sproat	1	1	J. H. Krusen	1	
W. E. Dornbach	2		R. D. Landrum	1	
M. Ichiyo	2		A. Malinovszky	1	
C. L. Sebring		1	C. R. Minton	1	
Geo. S. Tillotson		1	F. K. Pence	1	
A. Weber, Jr.		1	F. H. Rhead	1	
L. R. W. Allison	1		Will A. Rhodes	1	
F. H. Auld	1		R. F. Segsworth	1	
C. E. Bales	1		Mary G. Sheere	1	
L. E. Barringer	1		C. Saxton	1	
G. H. Brown	1		A. Silverman	1	
Lawrence H. Brown	1		Harry F. Spier	1	
B. M. Burchfiel	1		W. E. S. Turner	1	
R. R. Danielson	1		K. E. Ward	1	
M. S. Gifford	1		R. V. Widemann	1	
R. B. Gilmore	1		W. J. Watkins	1	
Herbert Goodwin	1		W. W. Wilkins	1	
Chas. O. Grafton	1		W. S. Williams	1	
R. K. Hursh	1		Hewitt Wilson	1	
S. M. Kier	1		Office	8	1
R. M. King	1				
			Total	52	5

The net increase for 1922 is:

	Personal	Corporation
Jan. 12, 1923	1611	216
Jan. 1, 1922	1350	139
	261	77

The gross increase by periods since December 1921 is as follows:

	Personal	Corporation	Total
December to February, 1922	68	5	73
February to May	81	10	91
May	13	13	26

	Personal	Corporation	Total
June	13	5	18
July	25	11	36
August	20	5	25
September	31	11	42
October	31	12	43
November	25	7	32
December to January 12, 1923	52	5	57
Total	359	84	443
Loss	98	7	105
Total	261	77	338

NEW MEMBERS RECEIVED FROM NOVEMBER 16, 1922, TO JANUARY 12, 1923

ASSOCIATE

Anderson, Edward, 206 Grosvenor Ave., Dayton, O., Superintendent, The A. A. Simonds-Dayton Co., Dayton, O.

Barkby, Harry, Decorating Manager, Chelsea China Co., New Cumberland, W. Va.

Botfield, Leonard B., 776 S. Swanson St., Philadelphia, Pa., Botfield Refractories Co.

Byrnes, A. Marietta, 63 Audubon Place, New Orleans, La.

Compton, Max D., 232 W. 42nd Place, Los Angeles, Calif., Ceramic Engineer, Los Angeles Pressed Brick Co.

Conaway, W. P., Production Manager and General Superintendent, Western Pottery Co., Denver, Colo.

Conover, Norman, Denny-Renton Clay & Coal Co., Taylor, Wash.

Corson, Kenneth P., 115 County-City Bldg., Seattle, Wash.

De Celle, Joseph A., 625 N. Genesee, Waukegan, Ill.

Didisheim, Frank Marcel, 234 Union St., Schenectady, N. Y. General Electric Co., Schenectady, N. Y.

Early, Joseph N., 240–246 Huron St., Brooklyn, N. Y.

Fessler, A. H., Asst. Cer. Engr., U. S. Bureau of Mines, Columbus, O.

Gerber, Albert C., Cer. Engr., John L. Mott Co., Trenton, N. J.

Goodwin, James Rushworth, 1267 Kenilworth Ave., Coshocton, O., Assistant to Factory Manager.

Graham, Charles E., 156 Hope St., Huntington Park, Calif., Asst. Chemist, Washington Iron Works.

Harrison, Wm. Nance, 4319 Iowa Ave., N. W., Washington, D. C., Laboratory Assistant, Bureau of Standards.

Hathaway, G. Frank, Genl. Supt., Wyman-Gordon Co., Worcester, Mass.

Homer, Marion, 368 Ashland Ave., Riverforest, Ill., Instructor of Art, McKinley High School.

Hull, Addis E., Jr., 1252 Euclid Ave., Zanesville, O., Assistant to Gen. Mgr., A. E. Hull Pottery Co., Crooksville, O.

Ikeda, Sertio, Nippon-Beer-Kosen-Kaisha, Amagasaki near Osaka, Japan.

Kamikawa, Michiro, Nippon-Beer-Kosen-Kaisha, Amagasaki near Osaka, Japan.

Kingsley, Charles B., Elizabeth, Pa., Asst. Mgr., Mississippi Glass Co., Floreffe, Pa.

Kreutzer, Walter E., 4640 Cliff Ave., Louisville, Ky., Foreman, Louisville Fire Brick Works.

Leahy, Arthur T., 5490 Ellis Ave., Chicago, Ill., Mgr., Plastic Dept., A. P. Green Fire Brick Co.

Lemmax, Wm. W., Box 59, Taylor, Wash., Chief Engineer, Denny-Renton Clay & Coal Co.,

Ligon, W. A., Box 246, Mayfield, Ky.

McConnell, Oscar F., Box 65, Taylor, Wash.

McVay, Thos. N., Instructor Ceramic Dept., University of Illinois, Urbana, Ill.

Middleton, G. Gregg, 7 Highland Grove, Worksop Notts, England, Works Manager, Selands Glass Works.

Miller, Robert V., Y. M. C. A., E. Liverpool, O., Ceramic Engineer, Knowles, Taylor & Knowles Co.

Mize, W. E., 514 Bangor Bldg., Cleveland, O., Ohio representative, Golding-Keene Feldspar Co.

Norton, Charles L., Professor of Physics, Mass. Inst. of Technology, Cambridge, Mass.

O'Brien, Thomas H., 27 Mathewson St., Providence, R. I.

Plank, Ross D., 532 La Salle Ave., Culver City, Calif., Glaze Chemist, Los Angeles Pressed Brick Co.

Poste, James, Denny-Renton Clay and Coal Co., Taylor, Wash.

Prentice, Ernest B., Box 513, Massillon, O., Vice Pres. and Secy., Massillon Refractories Co.

Pressler, E. E., 1835 Indianola Ave., Columbus, O., Laboratory Assistant, U. S. Bureau of Mines.

Riviere, Georges, 98, Boulevard de Courcelles, Paris, Ingenieur des Arts et Manufactures, Administrateur-Directeur de la Cie Gle de Construction de Fours.

Scalise, Antonio, Columbia Glass Co., Fairmont, W. Va.

Sloan, Burrow, 117 South 16th St., Philadelphia, Pa., Vice Pres., General Refractories Co.

Smart, Richard Addison, 114 Colorado Ave., Detroit, Mich., Detroit representative, American Refractories Co.

Smith, Ralph Ogden, 19 Chestnut St., Salem, N. J., Chemist, Salem Glass Works.

Tapper, E. H., 58 Holcomb St., Charlotte Station, Rochester, N. Y.

Taylor, Albert C., Woodworth Hotel, Robinson, Ill., Asst. Engr., W. A. Dase & Son Mfg. Co., Buffalo, N. Y.

Vernon, Cecil, 182 Shaftesbury Ave., Thorpe Bay, Essex, England, Engineer, Newalls Insulation Co.

Webb, R. S., Chemist, American Window Glass Co., Belle Vernon, Pa.

Weeden, Charles H., 1295 N. 4th St., Columbus, O.

Wehtje, Ernst, Bromölla, Sweden, Managing Director, Aktiebolaget Ifö Chamotte & Kaolinverk.

Wescott, Ernest Waters, °/₀ Niagara Alkali Co., Niagara Falls, N. Y., Research Engr., Kalmus, Comstock & Wescott.

Whitesell, Buhel E., Salina, Pa., Cer. Engr., Kier Fire Brick Co., Pittsburgh, Pa.

Wilson, Louis A., Chf. of Testing Dept., New Jersey Zinc Co., Palmerton, Pa.

Wormer, Grace, University Library, Iowa City, Iowa, Acting Librarian.

Corporation

All-in-One Plumbing Fixture Corp., 231 Ochsner Bldg., Sacramento, Calif.

Crescent China Co., Alliance, Ohio.

Sterling Grinding Wheel Co., Tiffin, O.

Vanderbilt, R. T. Co., 50 East 42nd St., New York City.

Weber Electric Co., Schenectady, N. Y.

WHO'S WHERE IN THE AMERICAN CERAMIC SOCIETY?

Frederick M. Becket of the Union Carbide Company, Niagara Falls, N. Y., is now located at 30 E. 42nd Street, New York, N. Y.

Edward R. Beidler, formerly of Toronto, Ont., Can., has moved to 356 E. National Ave., Brazil, Ind.

William J. Benner has notified the office of a change of address in Chicago from 6338 Wayne Ave., to 1409 Rosemont, Edgewater Station.

Leonard S. Briggs, of Lenox Inc., can be reached by addressing mail to Box 694, Trenton, N. J.

Wilson C. Broga formerly of Worcester, Mass., is now living in Greenfield, Mass.

Orello S. Buckner has moved from Holden, Mass., to 13 Charles St., Westboro, Mass.

John Lister Carruthers has severed his connection with The Denver Terra Cotta Co., and is now located at 66 S. 3rd St., Columbus, O.

Champion Ignition Company, Flint, Mich., is to be addressed in future as the A C Spark Plug Company.

Charles R. Fettke has changed his address from Carnegie Institute of Technology to 1118 Wightman St., Pittsburgh, Pa.

J. Parker B. Fiske has notified our office that his new address is 839 Beacon St., Boston, Mass.

Charles E. Golding of Golding Sons Co., has moved from 3rd & Hanover St., to 31 Columbia Ave., Trenton N. J.

Herbert Goodwin of the Crescent China Co., has been transferred from Niles, O., to Alliance O.

John S. Grainer has severed his connection with the Challenge Refrigerator Co., Grand Haven, Mich., to accept a position with the Estate Stove Co., his present address being 706 W. Main St., Hamilton, Ohio.

Maurice B. Greenough, formerly of Cleveland, O., is now located at 801 Volunteer Bldg., Chattanooga, Tenn.

Fred T. Heath of The Heath Unit Tile Co., informs this office that the firm is now located in the Puget Sound Bank Bldg., Tacoma, Wash.

J. W. Hepplewhite is now with the Johns Manville, Inc., Manville, N. J.

Interstate Corporation has been changed to The Bowman Coal Co., Broad Street Bank Bldg., Trenton, N. J.

Walter A. King of the Elyria Enameled Products Co., has changed his residence to 149 Branston, Elyria, O.

F. A. Kirkpatrick of Unionville, Mich., advises us that his new address is 1001 W. Pine St., Robinson, Ill.

George J. Lawrence, formerly of Chicago is now with the J. B. Ford Co., Wyandotte, Michigan.

P. William Lee writes that he is now with the Denver Terra Cotta Company at Denver, Colo.

Wm. R. Malkin informs us that he has taken a position with the B. F. Drakenfeld Co., Inc. at East Liverpool, O.

Frederic Merian has removed from 3415 Iowa street, Pittsburgh, to 815 St. James Street.

L. M. Merrit is now living at 481 Lexington Ave., Columbus, O.

Julius A. Miller who has been conducting work at Mellon Institute for H. Koppers Co., informs us that he has taken a position with Nesbit and Bollen, 403 Liberty Ave., Pittsburgh, Pa.

G. Z. Minton, of Kokomo, Ind., is now living at Elwood, Ind.

W. O. Mitcherling has asked that his address be changed from Landing, N. J., to Wilmington, Del.

Amos Potts recently of the Clay Products Co., Brazil, Ind., is now living at 47 N. 20th St., Columbus, O.

Prof. L. M. Richard is now living in Ocean Park, Cal., 2614 4th Street.

Edward J. Risch has notified us to change his address to 1534 Massosvoit Ave., Chicago, Illinois.

V. J. Roehm who has been with the Homer Laughlin China Company of Newell, W. Va., is now with Sec. 1, Division 9, Bureau of Standards, Washington, D. C.

E. M. Rupp, formerly of Keyport, N. J., is now in Middletown, O., 714 Lincoln Ave.

Harry W. Smith who has been living in Cleveland, O., writes that his address is 307 Fulton Bldg., Pittsburgh, Pa.

Peter Wachovec has notified us that he has moved to 9620 Park Heights Ave., Cleveland, O.

R. H. White has left Norton Company at Niagara Falls, N. Y. and is situated with the Abrasive Company of Canada, Ltd., Burlington St., Hamilton, Ont.

Richard P. White has returned from Hamilton, Ont. and is living at 121 S. Menard Ave., Chicago, Ill.

Y. Y. Wong has returned to Canton, China from Los Angeles, and is working with the Chen Kwong Co., Sap Pat Po.

REPORT OF CHICAGO LOCAL SECTION MEETING

On Dec. 2, 1922, the Chicago Section AMERICAN CERAMIC SOCIETY held at the Morrison Hotel, Chicago, the annual meeting which broke all standing records for attendance and interest. Sixty-five gathered around the banquet boards, which is more than double the second best number. We are not sure but that this sets a new record for any Sectional meeting not held in conjunction with any other organization. At any rate, the Executive Committee feels justly proud of the result of their efforts. Possibly the fact that a beautiful wired vase was given away (product of W. W. Wilkins, Lewis Institute) helped swell the crowd, as this was a "wonderful opportunity for somebody" to get a nice Christmas present for friend wife without paying for it. Mr. C. A. Underwood of the American Refractories Company, Joliet, was the lucky man. We heard someone near us remark that giving a lamp without a shade was like giving a set of books and paying the first installment, but we trust Mr. Underwood does not look at it in that light.

The program was sufficiently rich in material to be of interest to everyone present no matter with what branch of the industry he may have been allied. B. T. Sweely, of the Cribben-Sexton Stove Works, talked on "Defective Enamels," which, to the many enamel men present, held much food for thought. Mr. Sweely is very well qualified to talk on this subject for two reasons: the first being that he spent several months on special investigation work at the Bureau of Standards, Washington, and second, to use his own words, because he has made more defective enamels than any one else in the country.

We were very much pleased to have on our list of speakers Mr. E. O. Herman of the A. D. Little Co., Ind. Engineers, Boston, Mass., whose talk on the "Technical Man's Position in Production" held everyone's interest for more than half an hour. No one can listen to Mr. Herman without feeling some of his tremendous enthusiasm.

"Something Better in Enamel Smelters" by H. E. Davis, Northwestern Terra Cotta Company was a description of a furnace designed and built along principles adapted

for the most part from the Steel Industry in order to give the greatest possible efficiency to this process. The combustion chamber for the oil flame, the arch over the bath, and the insulation are the salient features of the furnace

Of greatest importance to the Chicago Section and the Ceramic Industries of this part of the country is the "Proposed Introduction of a Course in Ceramics in The New Crane Junior College of Chicago." Mr. Meyer, Assistant Principal of the school left his sick-bed to talk to us on this proposition, for the success of which he is putting forth every effort, and asking for our whole-hearted support. A committee has been appointed to coöperate with Mr. Meyer and he may rest assured that we are "with him" on anything so fine and worthy.

After the reading and discussion of the papers, the Annual Election of Officers was held, and the following were elected:

B. T. Sweeley	Pres.
W. W. Wilkins	Vice-Pres.
H. E. Davis	Sec'y. & Treas.
D. F. Albery	Ch'm. Prog. Comm.
Alan S. Wikoff	Ch'm. Memb. Comm.

Having seen what can be done to make a real live Local Section, the new officers are determined to uphold the reputation.

Respectfully submitted,

H. E. DAVIS, *Secretary*

MEETING OF THE PITTSBURGH DISTRICT SECTION OF THE AMERICAN CERAMIC SOCIETY

A meeting of the Pittsburgh District Section of the AMERICAN CERAMIC SOCIETY was held in the Fellow's Room of the Mellon Institute, Pittsburgh, Pa., on December 2, 1922, at 3: 00 P.M. with Mr. A. F. Greaves-Walker, the retiring chairman, and Dr. Alexander Silverman, the newly elected chairman, presiding.

The committee on nominations, submitted their report and on motion duly seconded the following officers were elected for the coming year:

Chairman	Alexander Silverman
Vice-Chairman	Francis C. Flint
Secretary	H. G. Schurecht
Treasurer	Thos. H. Sant
Councillor	Francis W. Walker, Sr.

The following reports of the committees were made:

PUBLICITY

Dr. Tillotson reported for this Committee, that four or five feature stories regarding the meeting and abstracts of some of the papers will be printed in the newspaper.

Mr. Greaves-Walker, Jr., suggested that one man act as a publicity man to take the events of each day and present them to the newspaper. *The Clay Worker* also expressed their willingness to publish notices regarding the convention.

Mr. Greaves-Walker, Sr., suggested that all publicity reports be put in writing for publication.

Dr. Silverman suggested putting announcements in some of the moving picture theatres.

SERVICE COMMITTEE

H. G. Schurecht reported that plans were being made whereby each division will know what papers are being presented in the other divisions.

SMOKERETTE COMMITTEE

It was decided to hold the smokerette on Tuesday night instead of Wednesday which date will be used for the Alumni party.

BANQUET COMMITTEE

Dr. Silverman stated that this would start promptly at 7:00 P.M. Speakers will be provided, honor guests will be heard from and souvenirs will be presented. A registration fee of $7.50 will be charged which will take care of the banquet smoker and entertainment of the ladies. Those members living in Pittsburgh will pay $10.00

ENTERTAINMENT OF LADIES

Mr. Greaves-Walker reported that the ladies will hold a reception and tea in room adjoining the general assembly room of the William Penn at 4 to 5 P.M., Monday. They will have a luncheon Tuesday noon at Heinzes. On Wednesday, a luncheon and Theatre Party will be held.

Ross suggested that a playette be given by the students in drama of Carnegie Tech.

TRIPS COMMITTEE

Mr. McDowell reported that four trips will be taken on Thurdsay and three on Friday. On Thursday one group will go to Beaver Falls escorted by F. W. Walker. A city trip to The Standard Sanitary Manufacturing Company, Pittsburgh Clay Pot Company and The Heinz Bottle Factory will be made. The third trip on Thursday will be to the glass plant at Creighton, Pa. The fourth will be to The By-Products Coke Works, Clairton, Pa.

On Friday one trip will be made through the Carnegie Steel Company, Homestead.

Another trip will be taken to the By-Products Coke Oven Plant, Hazleton, The Westinghouse Electric Company, and the National Tube Company.

A third trip on Friday will be taken to Washington, Pa., as trip to East Liverpool was cancelled because of the potter's strike.

Respectfully submitted,

H. G. SCHURECHT, *Secretary*

NOTES AND NEWS

CALENDAR OF CONVENTIONS

American Association of Flint and Lime Glass Mfrs.—April, 1923.
American Association of Ice & Refrigeration—Washington, D. C., Probably March, 1923.
AMERICAN CERAMIC SOCIETY—Pittsburgh, Pa., February 12–16, 1923.
American Dental Trade Association—Spring Lake, N. J., June, 1923.
American Face Brick Association—First Week in December, 1923.
American Face Brick Association, Southern Group—West Baden, Ind., November, 1923.
American Foundrymen's Association—Cleveland, Ohio, April 30–May 3, 1923.
American Gas Association—October, 1923.
American Hotel Association of United States and Canada—San Francisco, April, 1923.
American Institute of Mining and Metallurgical Engineers—New York City, February, 19–22, 1923.
American Society for Testing Materials—Place not determined, June, 1923.
American Zinc Institute—St. Louis, Mo., May 7 and 8, 1923.

Association of Scientific Apparatus Makers of the United States of America—Washington, D. C., April 20, 1923.

Chamber of Commerce of the United States of America—New York City, May 8–10, 1923.

Clay Products Association—Chicago, Ill., Third Tuesday in each month.

Common Brick Manufacturers' Association—Cleveland, Ohio, February 5, 6 and 7, 1923.

Dental Manufacturers' Club of the United States—Spring Lake, N. J., June, 1923.

Fire Underwriters' Association of the Northwest—Chicago, Ill., October 17–18, 1923.

International Chamber of Commerce—Rome, Italy, Week of March 19, 1923.

Manufacturing Chemists' Association—New York, June, 1923.

National Association of Brass Manufacturers, March, 1923.

National Association of Manufacturers of Pressed and Blown Glassware, Pittsburgh, March 13, 1923.

National Association of Manufacturers of the United States—New York City, Week of May 14, 1923.

National Association of Stove Manufacturers—Richmond, Va., May 9, 1923.

National Association of Window Glasss Manufacturers—Place and date not determined.

National Association Builders Board of Control—Des Moines, Ia., February, 1923.

National Board of Fire Underwriters—New York, May 24, 1923.

National Bottle Manufacturers' Association—Atlantic City, N. J.. Last of April, 1923.

National Brick Manufacturers' Association—Cleveland, Ohio, February 5–10, 1923.

National Clay Machinery Association—Cleveland, Ohio, February 7 and 8, 1923.

National Gas Appliance Manufacturers' Exchange—Kansas City, Mo., May, 1923.

National Gas Association of America—Louisville, Ky., Spring, 1923.

National Paving Brick Manufacturers' Association, December, 1923.

National Gas Association of America—Louisville, Ky., April 23–24, 1923.

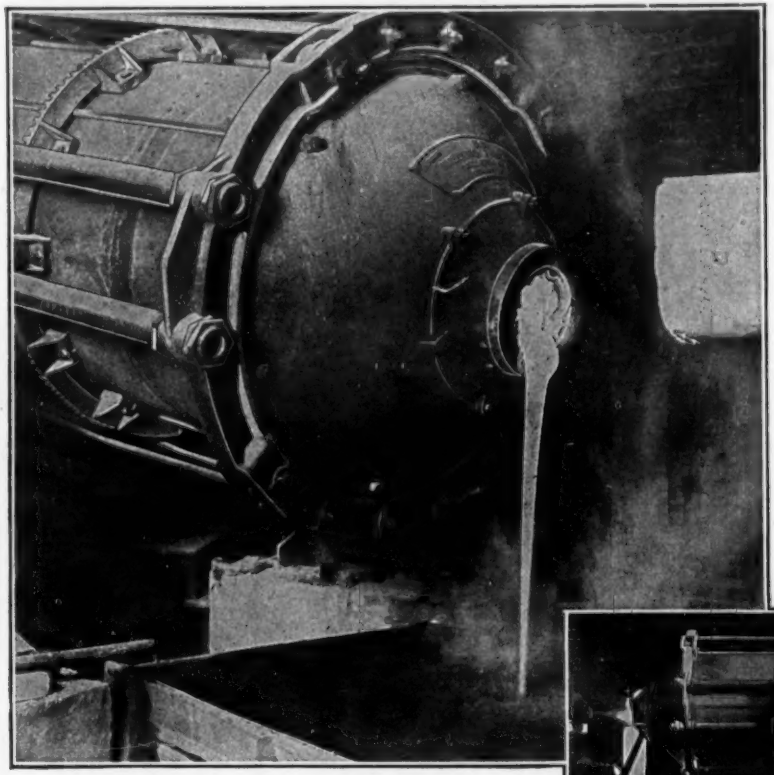
Refractories Manufacturers' Association—March 21, 1923.

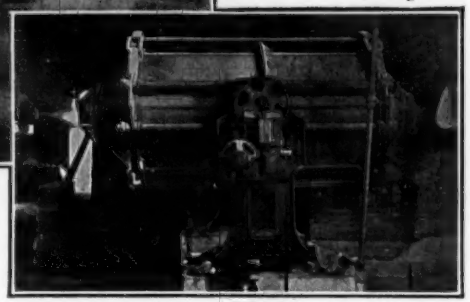
Sanitary Potters' Association—Pittsburgh, Pa., Monthly Meetings.

Southern Association of Stove Manufacturers—Louisville, Ky., March, 1923 (?).

Stoker Manufacturers' Association—May or June, 1923.

Tile Manufacturers' Credit Association—Beaver Falls, Pa., Quarterly Meetings.





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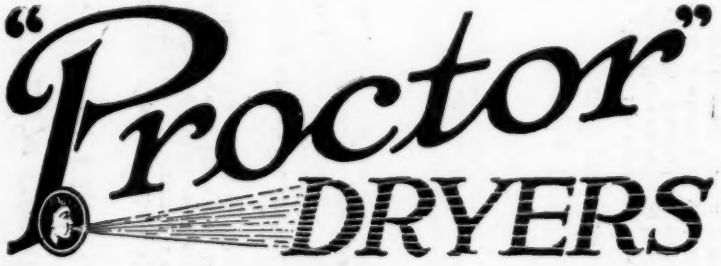

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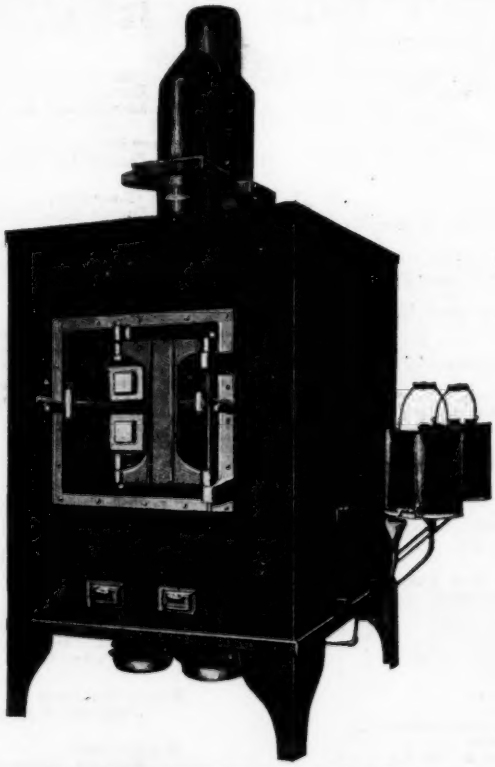

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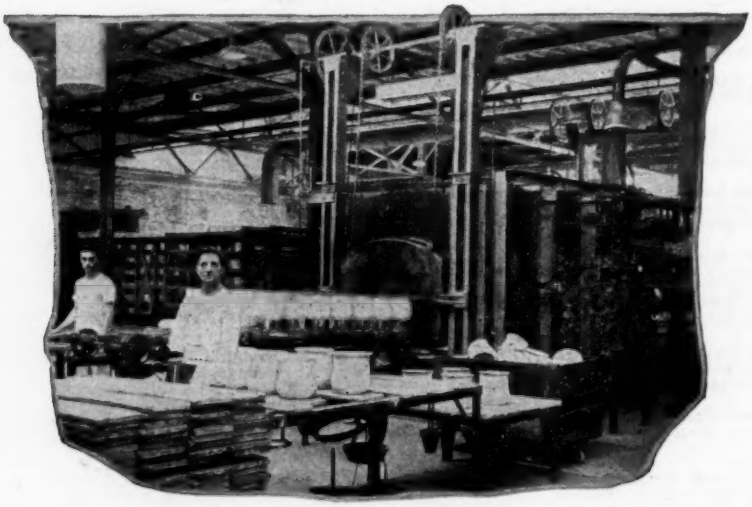

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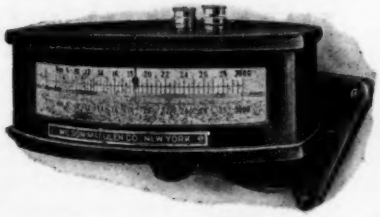

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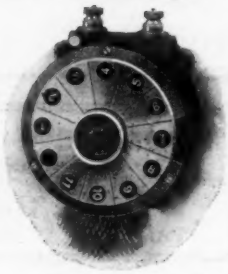

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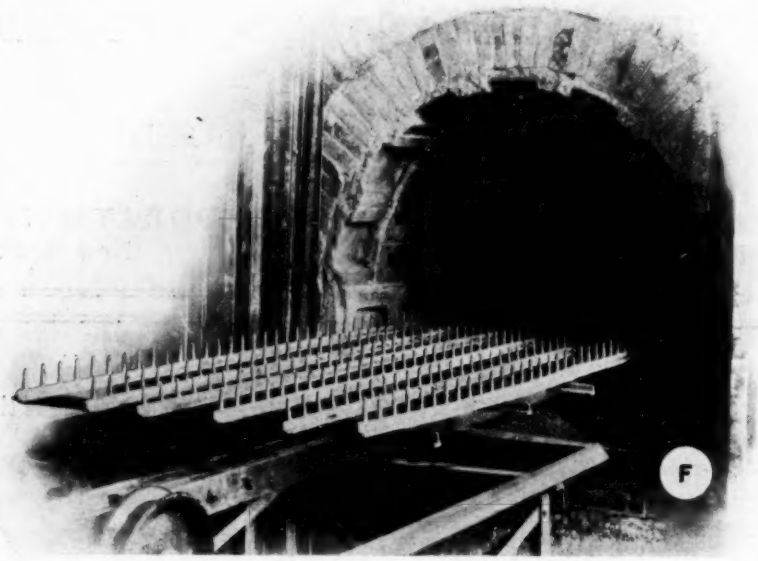

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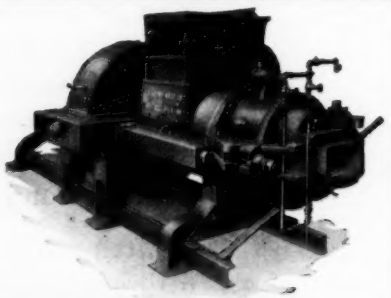

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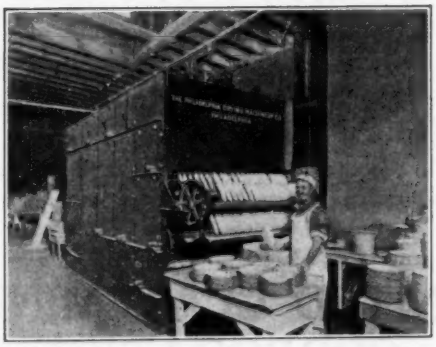

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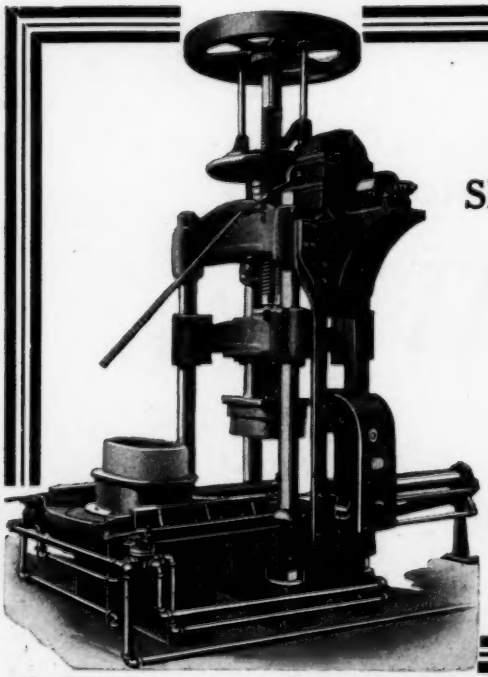

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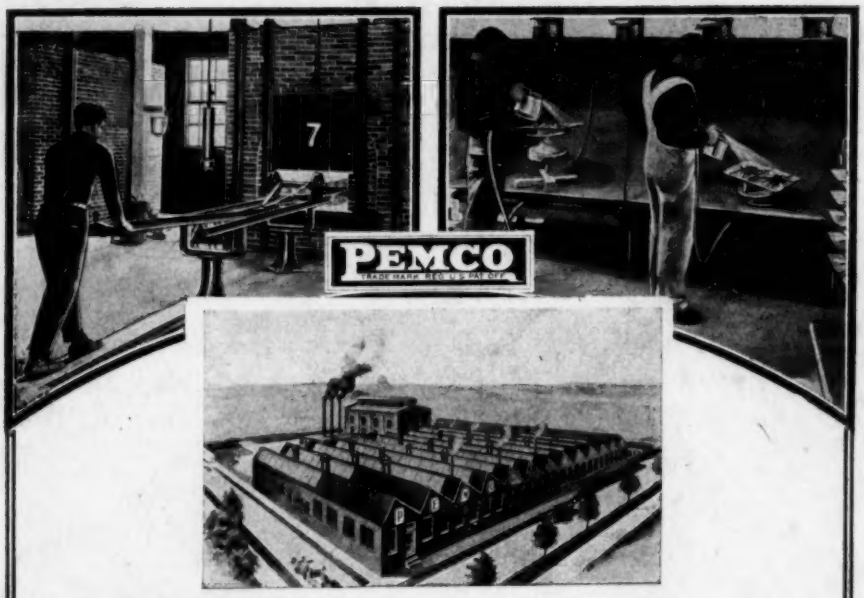

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